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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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VOL. CVI.—No. 2761.] *LONDON: FRIDAY, NOVEMBER 29, 1918.* [*Registered at the General Post Office as a Newspaper.*] PRICE...9d. BY INLAND POST ... 10½d.

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And Auxiliary Machinery as supplied to the Admiralty. 2170

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See Illustrated Advertisement December 13th.

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PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
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See page 99, Nov. 22. 6455

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All Gauges and Types.
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ELLAND, YORKS. 6819

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See Advertisement page 88, Nov. 22.

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RAILWAY CARRIAGES AND WAGONS,
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Iron and Steel
Tubes and Fittings. 6220
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 55.

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ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } Row's PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
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WATER SOFTENING and FILTERING. 5723

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CARDIFF WAREHOUSE—132, BUTE ST.
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See Advertisement page 28. 6462

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Valuers.
CONSULTING ENGINEERS, REFEREES, AND ARBITRATORS.
Established over 50 years. 7108
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Telegrams: "Radford, Sheffield." Telephone: 435.

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Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See Illus. Advt. last week, page 15. 7046

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Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Yarrow Patent
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STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

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Head, Wrightson & Co.,
LIMITED.
See Advertisement page 52, Nov. 22. 3402

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 6882
See Full Page Advt. page 72, Nov. 15.

Taylor & Challen
Presses. 8196
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM
See Full Page Advertisement Nov. 15.

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THOMAS SUMMERSON & SONS, LTD., DARLINGTON. 6974

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Patent
See's Hydro-Pneumatic Ash Ejector.
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4625

Tank Locomotives
Specification and Workmanship equal to Main Line Locomotives.
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Steam Hammers,
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Band Saws. 6479
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For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
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Founded 1854 by Sir WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 4661

NATIONAL FOREMEN'S ASSOCIATION.

The First Annual Delegate

MEETING of above will be held at the Imperial Hotel, Russell Square, W.C. 1, on SATURDAY and SUNDAY, DECEMBER 7th and 8th. Commencing Saturday at Two p.m.
All communications should be addressed to the SECRETARY, 81, High Holborn, W.C. 1. O 667

UNIVERSITY OF BRISTOL.
DEMOBILISATION.

Special Regulations have been

made to allow intending students who have served in the war or in the scientific service of the war to be admitted to matriculation by vote of Senate on their educational qualifications, without formal examination; and also to allow of such students entering the University in January if candidates in Arts; in January, or between January and May, if candidates in Science, Medicine, Dental Surgery or Engineering; and if grounds be shown, counting their first year's attendance as though it had commenced in October. Engineering students in special cases may be allowed to count one whole year's attendance.
Applications to the REGISTRAR. O 722

University of London,

University College Engineering Society.
There will be a Smoking Concert of this Society on Wednesday, DECEMBER 4th, at 6 p.m., to be followed by a Dance at 8 p.m. O 945

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 7096

A.M.I.C.E. and A.M.I.M.E.

Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—PENNINGTONS, 254, Oxford Road, Manchester.

TENDERS.

Tenders are Invited for the

PURCHASE as a going concern of the well-established business of the ANCHOR CHAIN CO., Oldham, manufacturers of all kinds of textile chains, motor chains, stampings, and steel press work generally. Tenders to be sent in not later than December 2nd.—Full particulars, with card to view, may be obtained from Messrs. HARRY L. PRICE & CO., Accountants, 15, Fountain Street, Manchester. O 896

TO BE SOLD BY TENDER.—A Prosperous ENGINEERING CONCERN in the West of England.

Messrs. FULLER, HORSEY, SONS, & CASSELL are instructed by the Proprietors, who are retiring from business, to invite

Tenders for the Purchase, in

one lot, as a going concern, of the BUSINESS and ASSETS (except book debts) of an old established ENGINEERING WORKS and FOUNDRY in an important town in the West of England. The property is freehold, with substantial buildings thereon, equipped with MODERN PLANT and MACHINERY, and the Stock, Stores, and Work in progress; as also the GOODWILL OF THE BUSINESS, together with the valuable collection of patterns and drawings will be included in the purchase.
Tenders must be in the form contained in the particulars of sale, and should be delivered under seal at the offices of Messrs. Fuller, Horsey, and Co., not later than Four p.m. on TUESDAY, December 10th, 1918.
Particulars, with plans and conditions of sale, are in course of preparation, and when ready may be obtained (price 5s. per copy) of FULLER, HORSEY, SONS, & CASSELL, 11, Billiter Square, London, E.C. 3. O 884

ALTERATION OF DATE.
KIDDERMINSTER.

TO BE SOLD BY TENDER, as a Current Going Concern, the BUSINESS and ASSETS (except Book Debts) of Messrs. PRUNELL, LAMB & CO., Road Traction and Agricultural Engineers and Machine Makers.

Messrs. FULLER, HORSEY, SONS & CASSELL are instructed by the Proprietor, who is resiring, to invite

Tenders for the Purchase, in

one lot, of the FREEHOLD ENGINEERING WORKS, situate in the main thoroughfare, known as Station Hill, Kidderminster, with substantial Buildings thereon, equipped with MODERN FIXED PLANT and MACHINERY. The whole of the Stock, Stores, Work in Progress, Loose Plant, Tools, Utensils and Patterns, and also the GOODWILL OF THE OLD-ESTABLISHED BUSINESS, will be included in the purchase, there being no obligation on the buyer to take anything at a valuation.
Tenders, which must be on the form contained in the Particulars of Sale, should be delivered at the Auctioneers' Offices by Four p.m. on THURSDAY, December 12th, 1918.
The Works may be viewed by orders only, to be obtained of the Auctioneers, and Particulars with Conditions of Sale had of H. G. IVENS, Esq., Solicitor, High Street, Kidderminster, or of Messrs. FULLER, HORSEY & CO., Mechanical Auctioneers and Valuers, 11, Billiter Square, London, E.C. 3. O 883

SALE OF PLANT at the POST OFFICE FACTORY, Bovay Place, Holloway, N. 7.

Tenders are Invited for

the PURCHASE and REMOVAL from the Post Office Factory, Bovay Place, Holloway, N. 7, of certain PLANT which is in efficient running order, but is no longer required. Specifications containing full particulars and forms of Tender may be obtained on application to the Controller, Post Office Stores Department, Studd Street Depot, London, N. 1.
Tenders will be received up to 10 a.m. on Friday, 6th December, 1918.
By order of the POSTMASTER-GENERAL.
General Post Office.
November, 1918. O 864

MIDLAND GREAT WESTERN RAILWAY OF IRELAND COMPANY.
OLD MATERIALS FOR SALE.

The Directors of the Midland Great Western Railway of Ireland Company are prepared to receive

Tenders for the Purchase

of OLD MATERIALS. Form of Tender, giving full particulars, can be obtained on application to the STOREKEEPER, General Stores Department, Broadstone Station, Dublin.
Tenders must be posted in time to be received at Broadstone on TUESDAY, 10TH DECEMBER.
By Order,
PERCY A. HAY, Secretary.
Broadstone Station, Dublin.
26th November, 1918. O 938

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—
1. Galvanized Corrugated Sheets.
2. Copper Plates and Rods.
3. Acid Open Hearth Steel Boiler Plates.
4. Hard Solid Drawn Copper Tubes.
5. Mild Steel Plates.

Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.
Tenders must be delivered in *separate envelopes*, sealed and addressed to the undersigned, marked "Tender for Galvanized Corrugated Sheets" or as the case may be, not later than Eleven a.m., on Friday, December 6th, 1918.
The Directors do not bind themselves to accept the lowest or any tender.
R. H. WALPOLE, Secretary.
Company's Offices, 48, Copthall Avenue, E.C.
London, 27th November, 1918. O 924

For Sale by Tender, as a Going

Concern, ENGINEERING WORKS, situate in N.W. district of London.
At present engaged on MUNITIONS COMPONENTS and other Contracts.
Housed in suitable Leasehold Buildings.
Containing PLANT and MACHINERY, up-to-date and in good running condition, including:—
Four GRIDLEY AUTOMATICS
Six CLEVELAND AUTOMATICS, &c., &c.
Invitations and Forms of Tender and Conditions of Sale will be forwarded to *bona fide* applicants, who can inspect the works by appointment. STOCK-IN-TRADE and General Stores to be taken by Purchaser at a Valuation.
Tenders must be received at the address below not later than Nine a.m. on FRIDAY, 13TH DECEMBER, 1918.
Address—
W. B. PRAT & CO.,
11, Ironmonger Lane,
London, E.C. 2. O 946

CITY OF LEEDS.
ELECTRICITY DEPARTMENT.

ENGINES, ALTERNATORS, and CONDENSING PLANT FOR SALE by Private Treaty.

Offers are Invited for the

following PLANT, discarded to make room for larger sets:—
One 2000 B.HP. Triple Expansion Three-Cylinder Vertical BELLISS ENGINE.
One 2000 B.HP. Triple Expansion Three-Cylinder Vertical McLAREN ENGINE.
Two Sets Horizontal Surface CONDENSING PLANT (by Mirrlees Watson), each having a cooling surface of 3400 square feet, one set being equipped with AIR PUMPING ENGINE and CIRCULATING ENGINE, and the other set with AIR PUMPING and CIRCULATING MOTORS.
Two 1400 Kilowatt Two-Phase ALTERNATORS and Exciters.
The plant is in good working order, and can be inspected by appointment.
Offers will be considered for the whole or any part of the plant.
The Specification, &c., may be obtained from the undersigned.
The Corporation do not bind themselves to accept any offer.
Offers are to be addressed to "The MANAGER, Electricity Department, 1, Whitehall Road, Leeds."
C. NELSON HEFFORD, Manager.
1, Whitehall Road, Leeds.
23rd November, 1918. O 774

APPOINTMENTS OPEN.

KENT EDUCATION COMMITTEE.
JUNIOR TECHNICAL SCHOOL, MAIDSTONE.

Required immediately, chiefly

for day work in the Junior Technical School, an ASSISTANT MASTER or MISTRESS qualified in science and mathematics. Initial salary, woman £200; man, with engineering science qualifications, £250.
Apply immediately to PRINCIPAL, Technical Institute, Maidstone.
E. SALTER DAVIES, Director of Education,
September, 1918 O 483

STANLEY JUNIOR TECHNICAL SCHOOL
South Norwood Hill,
London, S.E. 25.

The Board of Governors Invite

Applications for the following

POSITION on the Permanent Staff—
ASSISTANT MASTER to take charge of Drawing Office and to carry out the Course of Instruction in Practical Geometry and Technical Drawing. Commencing salary, £175.
Application Form and Particulars of Duties from the Headmaster. O 912

WARWICKSHIRE EDUCATION COMMITTEE.

The RUGBY FURTHER EDUCATION COMMITTEE invite

Applications for the Post of

ORGANISER of all Further Education, including the Evening Classes.
The appointment will be held under the Warwickshire Education Committee.
The salary will be £300 per annum.
Applications, with three testimonials or references should be forwarded not later than the 13th December next to the undersigned, from whom further particulars can be obtained.
By Order,
ARTHUR MORSON,
Clerk to the Committee.
Benn Buildings,
High Street, Rugby. O 818

METROPOLITAN WATER BOARD.
CHIEF ENGINEER.

The Metropolitan Water Board are prepared to receive

Applications for the Office of

CHIEF ENGINEER to the Board.
Organising experience in addition to engineering attainments will be a necessary qualification. It is proposed to make the appointment at a salary of £2,500 a year. The appointment will be held during the pleasure of the Board and the Chief Engineer will be required to give his whole time to the service of the Board and must not be directly or indirectly engaged in private practice or other paid employment. The Chief Engineer will not be required to contribute to the Board's Superannuation and Provident Fund nor will he be entitled to a Superannuation allowance.
Applications (which need not be accompanied by testimonials) must be on forms to be obtained from the Clerk of the Board, 2, South Place, Finsbury Pavement, London, E.C. 2, and must be delivered to him at that address in sealed envelopes endorsed CHIEF ENGINEER, not later than 10 o'clock a.m. on the 1st February, 1919. Personal canvassing is strictly prohibited and will disqualify candidates.
A. E. PILLING, Clerk of the Board.
2, South Place,
Finsbury Pavement,
London, E.C. 2,
23rd November, 1918. O 838

ESSEX COUNTY COUNCIL.
LEYTON HIGHER EDUCATION COMMITTEE.
ENGINEERING AND TRADE SCHOOL.

The Governors of the above-named School invite:

Applications for the Post of

HEAD MASTER. Experience in a Trade School or a Junior Technical Institution is desirable.
Candidates must hold the Degree of a British University in Engineering or Science, or its equivalent. Evening Classes conducted in the same building will be under the Headmaster's control, and he will supervise the Evening Classes of the Junior Commercial Institutes.
Salary £350 rising by annual increments of £20 to £500 per annum.
Forms of application, which should be returned not later than 14th December, may be obtained from Mr. J. H. NICHOLAS, County Offices, Chelmsford. O 921

Manager Required for Small

Steel Foundry in Hong Kong, which is being enlarged and reorganised. Applicants must be able to advise and superintend the laying out of modern steel foundries, including crucible, electric and open hearth furnaces. Applications from suitable discharged men would be considered. — Apply, stating age, experience, qualifications, salary required, references, &c., to BOX 782, care of LEATHWAIT & SIMMONS, 5, Birchin Lane, E.C. 3. M 718

Chief Cost Clerk Wanted

immediately, to take charge of department in large firm of Engineers and Founders. Practical experience of cost account keeping essential. Good opportunities for right man.—Address, stating age, full details of experience, references and salary required, O 608, Offices of ENGINEERING.

A Large Firm of Telephone

Engineers and Manufacturers in the Provinces (Government Controlled) HAVE VACANCIES in their Designs and Drawing Office sections. Applicants must have practical and technical experience. — Address, stating age, experience, and wages required, O 823, Offices of ENGINEERING.

A Large Firm of Engineers

in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4389, Offices of ENGINEERING.

Office Staff Vacancies Occur

For Index, Invoice, Entering, Assistant and Junior CLERKS in an Aeroplane Factory, London District. Preference shown to discharged soldiers and sailors. No one already on Government work or resident more than 10 miles away will be engaged. —Reply stating age, full particulars of experience and salary required to O 480, OFFICES of ENGINEERING.

Purchasing Assistant Re-

QUIRED, must have had general engineering training and some commercial experience. Suitable position for partially disabled man.—Apply, stating salary, and sending full particulars and testimonials, to ROWNTREE & CO., LTD., Engineering Dept., York. O 616

Estimating Assistant Required

in Aircraft and General Engineering establishment situated in East Anglia. Applicants to state age, experience, and salary required.—Address, O 836, Offices of ENGINEERING.

Required for Aircraft and

General Engineering Establishment situated in the Eastern Counties, a Man accustomed to setting out operations in Planning Department. Applicants to state age, experience and salary required.—Address, O 847, Offices of ENGINEERING.

Wanted at Once, Experienced

WORKS MANAGER for old-established malleable Iron Foundry employing 60 to 70 workpeople.—Write, giving full particulars, to O 613, Offices of ENGINEERING.

Wanted Mill Manager to take

Charge of large section rolling mills, cogging mill, sonkers, etc.; all sections up to the largest sizes of joints. Application with full particulars to be sent to O 820, Offices of ENGINEERING.

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to TAKE ENTIRE CHARGE of manufacture in large works. Good organiser and controller of workpeople. Accustomed to erection and assembling methods and to extensive output of repeat parts (interchangeable), chiefly in cast iron, at low costs. Highly experienced in utilisation of machine tools, &c. Conversant with drawings and with foundry and machine shop processes in their relation to the production of iron castings.—BOX 200, LONDON PRESS EXCHANGE, Ltd., 15, Strand, W.C. O 776

A London Manufacturing Firm

(working on the American principle with high-speed machinery, turning out a steel commodity) REQUIRES a First-class Intelligent MAN to take charge of the fitting shop. One who can hustle up on a breakdown and with a knowledge of electric motors, &c., for small repairs, preferred.—State work previously on and salary required to BOX 849, T. B. BROWNE'S Advertising Offices, 163, Queen Victoria Street, E.C. 4. O 816

Wanted, a First-class Man to

take entire charge of outside staff and supervise the erection, testing and putting to work of high-class engines, turbines, rolling mills and iron and steel works plant generally. Applicants must have had sound technical education and thorough workshop training and experience. State age, fullest particulars of training and experience and salary required. The post offers a comfortable permanency with good pay and prospects to a thoroughly capable man.—Address, O 785, Offices of ENGINEERING.

A London Manufacturing

Firm, working on the American principle of intensive output, turning out a steel commodity on high speed American machines, REQUIRE Two or Three Intelligent MEN, with previous experience as Tool Setters on Automatic Machines, to become operators.—State work previously on and wages required, to BOX 850, T. B. BROWNE'S Advertising Offices, 163, Queen Victoria Street, E.C. 4. O 817

A Firm opening Branch

Offices in Birmingham are ANXIOUS to SECURE the services of a thoroughly efficient SALES MANAGER for that district.
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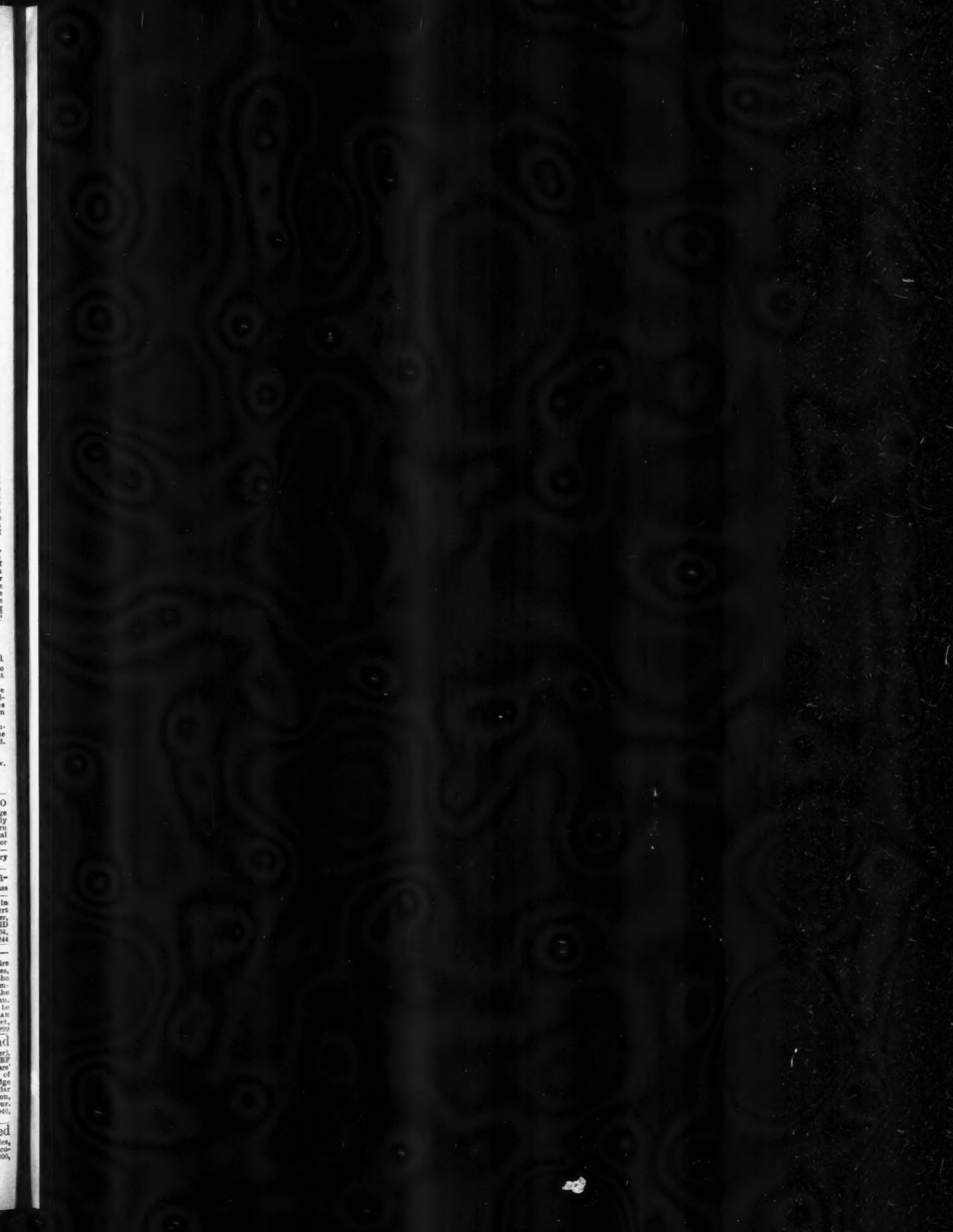


THE WHIRLING SPEED OF SHAFTS SUPPORTED IN THREE BEARINGS.

By Arthur Morley.

(*Concluded from page* 574.)

Section 8. *Distributed Load.*—In order to examine the effect of distributing the load in the illustrative cases of Sections 5, 6 and 7, the ratio of spans of 2 to 1 has been selected, and one-sixth of the total load was taken as concentrated at points 1, 3, 5, 7, 9 and 11 twelfths of l from either end. The numerical calculations are lengthy, and to show reasonably the relatively small differences they have to be made with some considerable degree of accuracy. The results are as follows :—

$$(\omega'')^2 = 505.6\ g\ E\ I/W\ l^3 \text{ against } 505.6\ g\ E\ I/W\ l^3$$

when the *total* load W is disposed as in Fig. 1, page 573 *ante*. The other results are

$$(\omega''/\omega')^2 = 1/1.029 \quad . \quad . \quad . \quad (26)$$
$$(\omega''/\omega_B)^2 = 1.349 \quad . \quad . \quad . \quad (27)$$
$$(\omega''/\omega_0)^2 = 1.190 \quad . \quad . \quad . \quad (28)$$

Thus the coefficient γ shows great variation, being very different in this case from that for a concentrated load. The error in Dunkerley's rule is also much greater than for the concentrated load on the same spans, while the error in the value of ω' is even smaller than before.

The calculations have also been made with the ratio of spans of 2 to 1, for the case of four loads each of one-eighth of the total placed at 1, 3, 5 and 7 twelfths of l from the outer end of the long span and two loads, each of one quarter of the total in the short span, placed 1 and 3 twelfths of l from the intermediate bearing. The results are :

$$(\omega'')^2 = 806\ g\ E\ I/W\ l \quad . \quad . \quad . \quad (29)$$
$$(\omega''/\omega')^2 = 1/1.028 \quad . \quad . \quad . \quad (30)$$
$$(\omega''/\omega_B)^2 = 1.349 \quad . \quad . \quad . \quad . \quad (31)$$
$$(\omega''/\omega_0)^2 = 1.209 \quad . \quad . \quad . \quad . \quad (32)$$

Section 9.—Returning to the illustrative example of Section 5 (*b*), of a shaft on three supports with a single load on each span, not only the ratio of the lengths of the two spans may vary, but (*a*) the positions in the spans (*b*) the relative magnitudes of the two loads and (*c*) the shaft diameters, may all vary independently.

(*a*) It is not proposed to examine the variation in the ratios $(\omega'/\omega'')^2$, $(\omega''/\omega_B)^2$ and $(\omega''/\omega)^2$ with variation in position of the loads, but it may be remarked that with two equal loads these ratios differ somewhat more from unity when, the load (at E) in the shorter span being centrally placed, the load in the longer span is somewhat nearer to the outer end (A) than to the support C, compared to the case of centrally-placed loads in each span (Section 5 (*b*)).

(*b*) The ratios $(\omega'/\omega'')^2$, $(\omega''/\omega_B)^2$ and $(\omega''/\omega_0)^2$ vary considerably with the ratio of magnitude of the two loads, being unity when the ratio of one load to the other is either zero or infinity, and reaching single maximum values for some intermediate value of the relative magnitude of the loads.

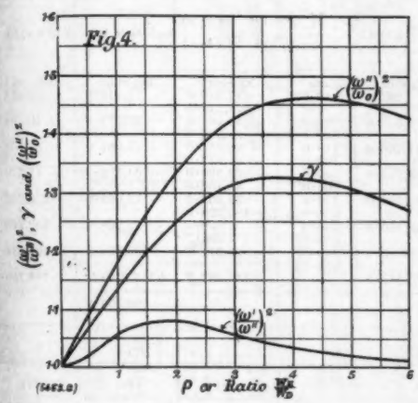
To illustrate the type of variation, the case of two spans in the ratio 16 to 9 ($a = 0{\cdot}64$) is chosen as this ratio (see Figs. 2 and 3, page 574 *ante*, shows about the maximum ordinates of $(\omega'/\omega'')^2$ for different span ratios with equal loads. Let the load in the longer span be W and that in the shorter be ρ W. Then the values of the ratios $(\omega'/\omega'')^2$, $(\omega''/\omega_B)^2$ and $(\omega''/\omega_0)^2$ are as given in Table III.

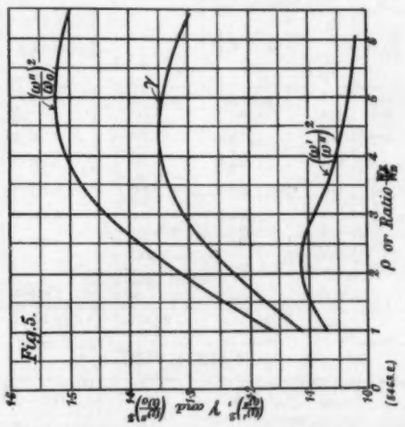
Table III.

ρ	$\left(\frac{\omega'}{\omega''}\right)^2$	γ or $\left(\frac{\omega''}{\omega_B}\right)^2$	$\left(\frac{\omega''}{\omega_0}\right)^2$
0·0	1·000	1·000	1·000
0·5	1·022	1·071	1·092
0·6	1·026	1·088	1·113
1·0	1·058	1·136	1·178
1·2	1·067	1·162	1·213
1·25	1·070	1·167	1·219
1·5	1·078	1·196	1·258
1·6	1·080	1·208	1·275
1·75	1·082	1·225	1·296
2·0	1·080	1·248	1·330
2·5	1·072	1·288	1·386
3·0	1·058	1·313	1·425
4·0	1·033	1·324	1·460
6·0	1·011	1·269	1·429

Table IV.

ρ	$\left(\frac{\omega'}{\omega''}\right)^2$	γ or $\left(\frac{\omega''}{\omega_B}\right)^2$	$\left(\frac{\omega''}{\omega_0}\right)^2$
0·0	1·000	1·000	1·000
1·0	1·07	1·112	1·157
1·5	1·097	1·174	1·20
2·0	1·113	1·227	1·315
3·0	1·089	1·311	1·433
5·0	1·0315	1·344	1·523
6·0	1·018	1·315	1·512





These values are shown plotted in Fig. 4. It will be observed that $(\omega'/\omega'')^2$ reaches a maximum when ρ is in the neighbourhood of 1·75, while the other two ratios reach maxima for a considerably greater value of ρ. It may further be noticed that the ratio (ω''/ω_B) is far from being constant and that ω''/ω_0 differs somewhat widely from unity, which value it should have if Dunkerley's empirical approximation held good in this case.

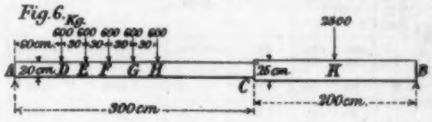
(*c*) It is proposed to examine a single case where the diameter of the shaft is different in the two spans, but otherwise is constant. Taking centrally-placed loads, and spans in the ratio 1·5 to 1 (*i.e.*, $a = 0{\cdot}6$), let the value of I be 2·5 times as great in the short span as in the longer one. The calculation of ω' and ω'' is somewhat laborious; it follows somewhat the lines of the calculation for the case of several loads in Section 10, but for working out the critical speed for two loads with several values of the ratio ρ of their magnitudes, time can be saved by first determining the deflection coefficients for the deflections produced at D and E by unit loads, first at D alone and then at E alone. The four coefficients really reduce to three since unit load at D produces at E the same deflection as unit load at E produces at D. The results are shown in Table IV and Fig. 5.

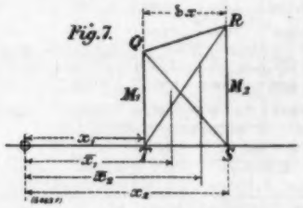
It will be noticed that the ratios rise to higher maxima than for the shaft of constant diameter shown in Fig. 4, and this case of a short span with a larger diameter of shaft and heavier load is not without application to actual machines driven by some form of motor or prime mover on the same shaft, and the conclusion to be drawn is that such cases require treating on their individual data, and that an empirical rule applicable to different circumstances of support and loading cannot safely be used to give a result within, say, 10 per cent., though doubtless, with suitable coefficients, such rules may give very close results for similar but not identical conditions.

Section 10. *Turbo-Blower Type of Loading and Support.*—A numerical example will be necessary to deal with the case of a shaft of varying diameter carrying several loads. The loads (which include the weight on the shaft) and the supports are shown in Fig. 6. In actual examples of turbo-blowers there would generally be more variations in diameter of the shaft, and the loads might be somewhat more distributed. This does not affect the method of treatment and the rather simpler but quite typical data are chosen :—

(*a*) To more clearly illustrate the method of calculation, and (*b*) to facilitate nearly exact calculation, and so to illustrate fairly accurately the ratio of the first approximation (ω') to the second approximation (ω'') of the critical speed where ω' and ω'' differ by a small proportion only.

To calculate the deflections y', tabulation is used as an alternative to graphical methods, one of which the writer has illustrated previously for the case of support in two bearings.* First the "prop" at C is assumed to be removed and the deflections of the shaft simply supported at A and B are calculated by Table V, page 602, in which F stands for shearing force, M for bending moment, I for amount of inertia :





$\Gamma = \pi\ d^4/64$) and $I_0 = \pi\ 20^4/64 = 7854$ (cm.)^4, A or $\Sigma\ (d\ A)$ stands for

$$\int M\ \frac{I_0}{I} d\ x \text{ and } A\ x \text{ or } \Sigma\ (x\ .\ \delta\ A) \text{ for } \int (M\ \frac{I_0}{I}\ x)\ d\ x.$$

The elements A and $x \cdot \delta$ A are found in two parts in Columns (11) and (15) of Table V, as indicated in Fig. 7, which shows an element of the bending-moment diagram for a length $\delta\ x$ between consecutive loads.

$$\delta\ A_1 = \text{area T Q S} = \tfrac{1}{2}\ M_1\ .\ \delta\ x,$$
$$A_2 = \text{area Q R S or area T R S} = \tfrac{1}{2}\ M_2\ .\ \delta\ x,$$
$$x\ \delta\ A = \overline{x_1}\ .\ A_1 + \overline{x_2}\ A_2 \text{ where}$$
$$\overline{x_1} = x_1 + \tfrac{1}{3}\ \delta\ x \text{ and } \overline{x_2} = \overline{x_1} + \tfrac{2}{3}\ \delta\ x.$$

To find the deflection y at any point then,

$$E\ I_0\ .\ y = x\ \left\{\frac{1}{l}\ \Sigma_0^l\ (x\ .\ \delta\ A) - \Sigma_0^l\ (\delta\ A)\right\} + \Sigma_0^x\ (\delta\ A)\Big\} - \Sigma_0^x\ (x\ .\ \delta\ A) \quad (33)$$

For example, at the point C,

$$E\ I_0\ .\ y_c = 300\{-188{,}750 \times 10^4/500 + 23{,}444{,}100 - 28{,}800{,}000\} + 4{,}022{,}000{,}000 = 1{,}282{,}700{,}000 \text{ kg.} - (\text{cm.})^3\ . \quad (34)$$

To find the reaction of the prop at C, the principle of Wilson's method† may most conveniently be used. If the reaction at the prop at C is P (kilogrammes) the deflection at C due to P may be found by another table such as Table V. But for a single load and only one change in the shaft diameter, the results may be written down without a table. Thus the (downward) reaction at A if P acted alone (upward) would be $\frac{2}{3}$ P, and at B, $\frac{1}{3}$ P. The bending moment at C will be (see Fig. 8, page 602) :

$$\tfrac{2}{3}\ P \times 300 = 120\ P \text{ kg.-cms.}$$

* "Calculation of Vibration and Whirling Speeds." Engineering, July 30 and August 13, 1909.

† "Strength of Materials," Art. 90.

At C $\delta A = \frac{1}{2} \cdot 120\,P \times 300 = 18{,}000\,P$
At B $\delta A = \frac{1}{2} \times 120\,P \times 200 \times 0.4096 = 4{,}915.2\,P$

$\Sigma(\delta A) = 22{,}915.2\,P$

A to C $\Sigma(x\,\delta A) = 18{,}000 \times P \times 200 = 3{,}600{,}000\,P$
C to B $\Sigma(x\,\delta A) = 4{,}915.2 \times 366.67\,P = 1{,}802{,}240\,P$

$5{,}402{,}240\,P$

Deflection at C, due to reaction P, is given by,

$$E I_0 . y_c = 300\{5{,}402{,}240/500 - 4{,}915\}P - 3{,}600{,}000\,P = -1{,}833{,}216 . P \text{ kg.} - (\text{cm.})^3 \quad . \quad . \quad (35)$$

and since the resultant deflection at C due to the reaction and load together is to be zero, from (34) and (35),

$$1{,}282{,}700{,}000 - 1{,}833{,}216\,P = 0 \quad \text{or} \quad P = 699.7 \text{ kg.} \quad (36)$$

To find the deflections y' at each load there is some choice of method. A new table, such as Table V, may be made with values of M, &c., amended to allow for the upward force P, or the deflections resulting from the loads and the supporting force P may be found separately and added algebraically, or as shown in Table VI, the values of $\Sigma(\delta A)$ and $\Sigma(x \cdot \delta A)$ resulting from P, for each load-point may be written down and added (algebraically) to those from Table V for the loads alone. The values of $\Sigma(\delta A)$ and $\Sigma(x \cdot \delta A)$ at distances x from A, for the prop reaction P are easily written down from the formulæ, from A to C,

$$\Sigma(\delta A) = \tfrac{1}{2} P x^2, \quad \Sigma(x\,\delta A) = \Sigma(\delta A) \times \tfrac{2}{3} x \quad . \quad (37)$$

and for the points K and B simple additions to the values at C, obvious from Fig. 9, may be used.

The columns (5) and (6) of Table VI substituted in formula (33), give the figures in Column (7), the formula being :

$$10^{-4} E I_0 . y' = x/10\{11{,}195 + 10^{-3} \Sigma_0^x(\delta A)\} - 10^{-4} \Sigma_0^x (x \cdot \delta A) \quad . \quad . \quad . \quad (38)$$

Taking $E = 2 \times 10^6$ kg. per square centimetre, the third column of Table VII is immediately written down from Column (6) of Table VI, and the remaining columns are derived by simple arithmetic.

And the totals of Columns (4) and (6), Table VII, inserted in (2), give :

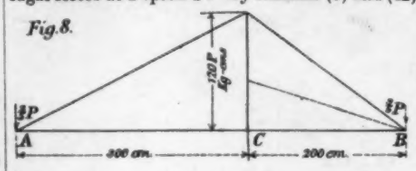
$$(\omega')^2 = g/y'_m = \frac{g\,\Sigma(W\,y')}{\Sigma(W\,y'^2)} = g\,I_0 . 10^{-2}\,\frac{15{,}574.35}{55{,}019.6} = \frac{g\,I_0}{100} \times \frac{1}{3.571} = \frac{981 \times 78.54}{3.571} = 21{,}570 \quad . \quad (39)$$

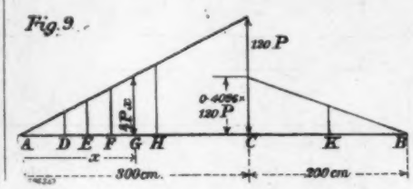
$$\omega' = \sqrt{21{,}570} = 146.8 \text{ radians per second} . \quad (40)$$

or $N' = 1{,}402$ revs. per minute. . . (41)

and $y'_m = 357.1/I_0 \quad . \quad . \quad . \quad . \quad (42)$

To calculate the second approximation ω'' it is necessary to find the deflections y'' resulting from the modified forces W′ which result from the centrifugal forces at a speed ω'. By formulæ (3) and (42),





$$W' = W . \frac{y' I_0}{357.1} \quad . \quad . \quad . \quad . \quad (43)$$

and the values of $y' I_0$ are found in Column (3) of Table VII. The values of W′ are entered in Column (4) of Table VIII, and the rest follows as in Table V. Then as in (34), with no prop at C :

$$E I_0 . y_c = 300\{941{,}632.4 \times 10^4/500 + 54{,}904{,}800 - 52{,}054{,}800\} + 8{,}433{,}857{,}000 = 3{,}639{,}062{,}600 \text{ kg. (cm.)}^3 \quad . \quad . \quad (44)$$

Hence from (44) and (35) the modified magnitude of the prop reaction at C is :

$$P = 3{,}639{,}062{,}600 \div 1{,}833{,}216 = 1{,}985.1 \text{ kg.} \quad . \quad (45)$$

The remainder of the work is as before, Table IX being similar to Table VI and Table X to Table VII, the final formula for y'' being :

$$10\,E I_0 . y'' = x/10\{12{,}031.5 - 10^{-3} \Sigma_0^x(\delta A)\} - 10^{-4} \Sigma_0^x (x . \delta A) \quad (46)$$

And, finally,

$$(\omega'')^2 = g/y''_m = \frac{g\,\Sigma(W'\,y'')}{\Sigma(W' . y''^2)} = g\,I_0 \times 10^{-2} \times \frac{16{,}828}{64{,}896} = \frac{g\,I_0}{100} \times \frac{1}{3.856} = \frac{981 \times 78.54}{3.856} = 19{,}960 \quad . \quad (47)$$

and $y''_m = 385.6/I_0$ cm. . . . . (48)

$$\omega'' = \sqrt{19{,}960} = 141.3 \text{ radians per second} . \quad (49)$$

or $N'' = 141.3 \times 30/\pi = 1{,}349$ revs. per minute (50)

$$(\omega''/\omega')^2 = 3{,}571/3.856 = 1/1.080 \quad . \quad . \quad (51)$$

$$\omega''/\omega' = 1/1.040 \quad . \quad . \quad . \quad (52)$$

or ω'' is about 4 per cent. less than ω'.

TABLE VI.

	For Prop only.			For Load and Prop.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Point.	x	$10^{-3}\sum_0^x(\delta A)$	$10^{-4}\sum_0^x(x\delta A)$	$10^{-3}\sum_0^x(\delta A)$	$10^{-4}\sum_0^x(x\delta A)$	$10^{-4} y' E I_0$
D	60	504	2,015	− 2,700	− 10,801	61,771
E	90	1,134	6,801	− 5,805	− 33,293	81,803
F	120	2,015	16,128	− 9,451	− 71,630	92,558
G	150	3,149	31,486	−13,096	−120,784	92,269
H	180	4,534	54,408	−16,202	−171,824	81,644
C	300	12,595	251,890	−16,205	−150,310	0
K	400	15,174	340,636	−10,887	+ 38,504	− 26,184
B	500	16,034	377,990	− 7,410	+189,240	0

TABLE VII.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Point.	x	$y' I_0$	$10^{-2} W y' I_0$	$y'^2 I_0^2$	$10^{-4} W y'^2 I_0^2$	$\frac{y'}{y'_m}$
D	60	308·85	1,853·13	95,380	5,722·8	0·8648
E	90	409·01	2,454·09	167,300	10,038	1·145
F	120	462·79	2,776·74	213,400	12,804	1·296
G	150	461·34	2,768·07	212,800	12,768	1·292
H	180	408·22	2,449·32	166,700	10,002	1·143
K	400	−130·92	+3,273·00	17,140	4,285	0·3664

TABLE V.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Point on Fig. 4.	δx	x	W	$\frac{W x}{1000}$	F	$\frac{\delta M}{100}$	$\frac{M}{100}$	$\frac{I_0}{I}$ or $\left(\frac{20}{d}\right)^4$	$10^{-2} M \frac{I_0}{I}$	$10^{-2}(\delta A_1)$ $10^{-3}(\delta A_2)$	$10^{-3}\delta A$	$10^{-3}\Sigma(\delta A)$	$\frac{x_1}{x_2}$	$10^{-4}\delta(A_1 x)$ $10^{-4}\delta(A_2 x)$	$\delta(A x) \times 10^{-4}$	$\Sigma(\delta A x) 10^{-4}$
	cm.	cm.	kg.	kg.-cm.	kg.	kg.-cm.	kg.-cm.		kg.-cm.	kg.-cm.²	kg.-cm.²	kg.-cm.²	cm.	kg.-cm³	kg.-cm.³	kg.-cm.³
D	60	60	600	36	−1,780	−1,068	−1,068	1·0	− 1,068·0	− 3,204·0	− 3,204·0	− 3,204·0	40·0	− 12,816·0	− 12,816·0	− 12,816·0
										− 1,602·0			70·0	− 11,214·0		
E	30	90	600	54	−1,180	− 354	−1,422	1·0	− 1,422·0	− 2,133·0	− 3,755·0	− 6,939·0	80·0	− 16,064·0	− 27,278·0	− 40,094·0
										− 2,133·0			100·0	− 21,330·0		
F	30	120	600	72	− 580	− 174	−1,596	1·0	− 1,596·0	− 2,394·0	− 4,527·0	−11,466·0	110·0	− 26,334·0	− 47,664·0	− 87,758·0
										− 2,394·0			130·0	− 31,122·0		
G	30	150	600	90	+ 20	+ 6	−1,590	1·0	− 1,590·0	− 2,385·0	− 4,779·0	−16,245·0	140·0	− 33,390·0	− 64,512·0	− 15,270·0
										− 2,385·0			160·0	− 38,160·0		
H	30	180	600	108	620	186	−1,404	1·0	− 1,404·0	− 106·0	− 4,491·0	−20,736·0	170·0	− 35,802·0	− 73,962·0	−226,232·0
								1·0	+ 60·0	− 8,424·0			220·0	−185,328·0		
C	120	300	0	(360)	1,220	+1,464	+ 60	0·4096	+ 24·58	+ 360·0	− 8,064·0	−28,800·0	260·0	+ 9,360·0	−175,968·0	−402,200·0
										+ 122·0			333·33	+ 4,096·7		
K	100	400	− 2,500	− 1,000	1,220	+1,220	+1,280	0·4096	+ 523·29	+ 2,616·5	+ 2,739·4	−26,080·6	366·67	+ 95,971·7	+100,068·3	−302,131·7
										+ 2,616·5			433·33			
B	100	500	0	(− 640)	−1,280	−1,280	0	0·4096	0·0	0·0	+ 2,616·5	−23,444·1	—	+113,381·7	+113,381·7	−188,750·0
										−23,444·1	−23,444·1				−188,750·0	

TABLE VIII.

(1	(2	(3	(4	5	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Point on Fig. 4.	δx	x	W	$\frac{W x}{1000}$	F	$\frac{\delta M}{100}$	$\frac{M}{100}$	$\frac{I}{I_0}$ or $\left(\frac{20}{d}\right)^4$	$10^{-2} M \frac{I_0}{I}$	$10^{-3}(\delta A_1)$ $10^{-5}(\delta A_2)$	$10^{-5}\delta A$	$10^{-3}\Sigma(\delta A)$	$\frac{x_1}{x_2}$	$10^{-4}\delta(A_1 x)$ $10^{-4}\delta(A_2 x)$	$\delta(A x) \times 10^{-4}$	$\Sigma(\delta A x) 10^{-4}$
	cm.	cm.	kg.	kg.-cm.	kg.	kg.-cm.	kg.-cm.		kg.-cm.	kg.-cm.²	kg.-cm.²	kg.-cm.²	cm.	kg.-cm.	kg.cm.³	kg.-cm.³
D	60	60	518·9	31·134	2,408·54	− 1,445.124	− 1,445.124	1·0	− 1,445·1	− 4,335·3	− 4,335·3	− 4,335·3	40·0	− 17,341·2	− 17,341·2	− 17,341·2
										− 2,167·6			70·0	− 15,173·2		
E	30	90	687·0	61·830	− 1,889·64	− 566·89	− 2,012·02	1·0	− 2,012·0	− 3,018·0	− 5,185·6	− 9,520·9	80·0	− 24,144·0	− 39,317·2	− 56,658·4
										− 3,018·0			100·0	− 30,180·0		
F	30	120	776·6	93·192	− 1,202·64	− 360·79	− 2,372·81	1·0	− 2,373·8	− 3,560·7	− 6,578·7	−16,099·6	110·0	− 40,167·7	− 70,347·7	−127,006·1
										− 3,560·7			130·0	− 46,289·1		
G	30	150	775·2	116·28	− 426·04	− 127·81	− 2,500·62	1·0	− 2,500·6	− 3,750·9	− 7,311·6	− 23,411·2	140·0	− 52,512·6	− 98,801·7	−225,807·8
										− 3,750·9			160·0	− 60,014·4		
H	30	180	685·8	123·444	349·16	+ 104·75	− 2,395·87	1·0	− 2,395·9	− 3,593·9	− 7,344·8	−30,756·0	170·0	− 61,096·3	−121,110·7	−346,918·5
									− 1,153·9	−14,375·4			220·0	−316,258·8		
C	120	300	0·0	(425.880)	1,034·96	+ 1,241·95	− 1,153·92	0·4096	− 472·6	− 6,923·4	−21,298·5	−52,054·8	260·0	−180,208·4	−496,467·2	−843,385·7
										− 2,363·0			333·33	− 78,766·7		
K	100	400	−916·0	−366·4	1,034·96	+ 1,241·96	− 118·96	0·4096	− 48·7	− 243·5	− 2,606·5	−54,661·3	366·67	− 8,928·3	− 87,695·0	−931,080·7
										− 243·5			433·33	− 10,551·7		
B	100	500	0·0	(+ 59·5)	118·96	+ 118·96	0·0	0·4096	0·0	0·0	− 243·5	−54,904·8	—	0·0	− 10,551·7	−941,632·4
										−54,904·8	−54,904·8			−941,632·4	−941,632·4	

TABLE IX.

	For " Prop " only.			For Load and " Prop."		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Point.	x	$10^{-3}\sum_0^x(\delta A)$	$10^{-4}\sum_0^x(x\delta A)$	$10^{-3}\sum_0^x(\delta A)$	$10^{-4}\sum(x\delta A)$	$10^{-4} y'' E I_0$
D	60	1,429·9	5,716	− 2,905·5	− 11,625	− 66,381
E	90	3,218·0	19,294	− 6,303·0	− 37,364	88,916
F	120	5,706·0	45,755	− 10,494·0	− 37,364	88,916
G	150	8,933·0	89,326	− 14,478·0	− 136,482	99,777
H	180	12,863·0	154,355	− 17,893·0	− 192,554	87,038
C	300	35,732·0	714,612	− 16,323·0	− 128,774	0
K	400	43,048·0	966,384	− 13,613·0	+ 35,303	− 27,977
B	500	45,488·0	1,072,358	− 9,417·0	+ 130,726	0

SINGAPORE HARBOUR AND DOCK WORKS.

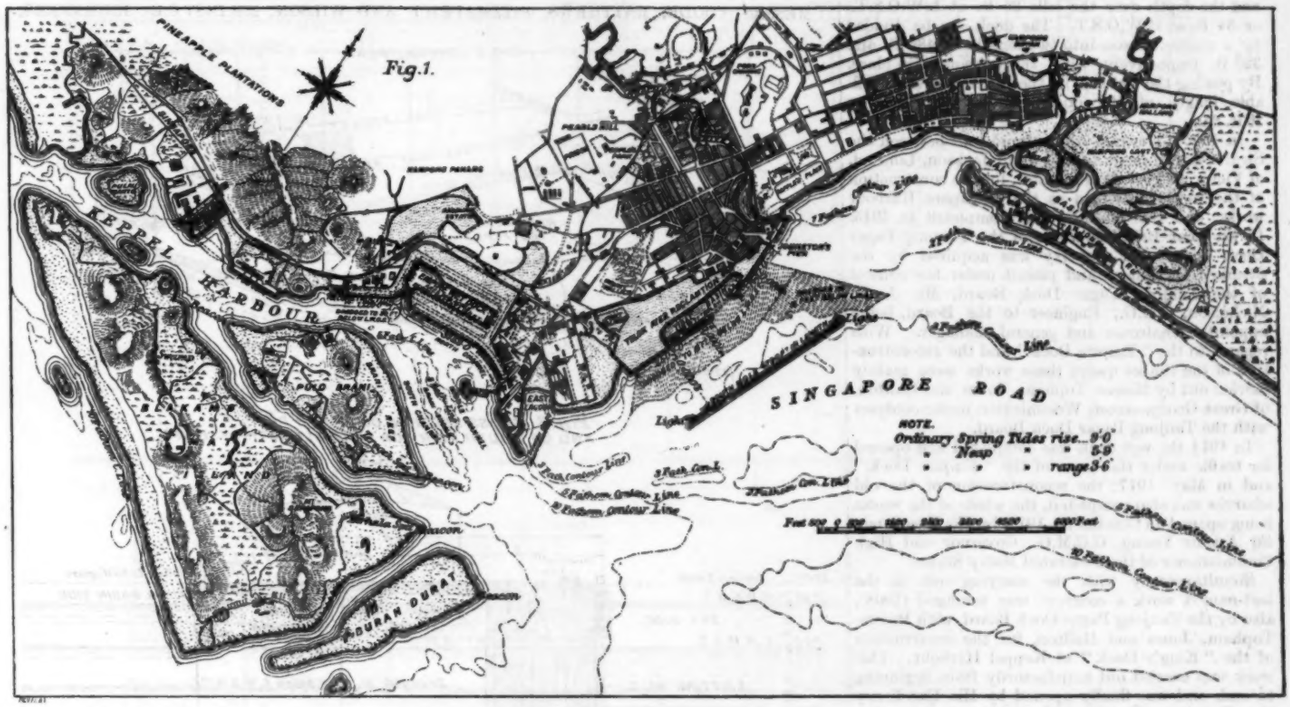


TABLE X.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	x	W'	y''I	10W'y''I	y''I	10 Wy''I
D	60	518·9	331·90	1,722	110,200	6,612
E	90	687·0	444·58	3,055	197,600	11,856
F	120	776·6	504·47	3,917	254,000	15,240
G	150	775·2	498·88	3,868	248,900	14,934
H	186	685·8	435·19	2,985	189,400	11,364
K	400	−916·0	−139·88	1,281	19,560	4,890
			Total	16,828	Total	64,896

It will be noticed from the deflections under the first assumed (gravitational) forces the maximum deflection is at the point F where y'I is 462·79, hence from (48) and (25):

$$(\omega''/\omega_n)^2 = \gamma = y'_{max.}/y''_m = 462{\cdot}79/385{\cdot}6 = 1.20 \quad (53)$$

This coefficient has already been shown to differ widely for different forms of loading in the case of a shaft supported in three bearings, and this shows it also differs for such loading as the present from the value appropriate to many turbo-machine shafts where it is said to have the value 1·07 to 1·08.*

To find the critical speed by Dunkerley's empirical rule it would be necessary to find the deflections at each load when that load only is on the shaft, and thus would involve new calculations entirely.

SECTION 11. *Conclusion.*—It has been demonstrated for the three bearing type of support, by the case of two loads under widely varying conditions of relative mass and span ratios, the summation formula (2) gives a much closer approximation to the critical speed than does Dunkerley's empirical rule (21). Also that the coefficient γ in Baumann's method varies widely with varying conditions of load and support.

It has further been pointed out that a second approximation may be made by the summation formula (4), which is very close to the true critical speed in all cases and, if need be, further successive approximations may be made in the same way.

A typical case of practical loading has been worked out by tabulation as an alternative to finding the deflections graphically.

It remains to be remarked that the methods employed or mentioned as alternatives are applicable to a continuous shaft in any number of supporting bearings, although with more than three supports the work is generally of necessity increasingly laborious.

* Baumann, *loc. cit.*, p. 813.

RECENT HARBOUR AND DOCK WORKS AT SINGAPORE, STRAITS SETTLEMENTS.

SINGAPORE is the capital town of the Straits Settlements, and is situated on the southern shore of the island of that name. The island lies at the extreme southern extremity of the Malay Peninsula, being separated from the mainland by the Straits of Johore. The island is approximately of the same area as the Isle of Wight, and the town of Singapore is only some 60 miles or 70 miles north of the equator. The harbour itself is almost entirely landlocked by the surrounding islands, and being so near the equator is practically free from severe gales.

Singapore is an exceedingly important shipping centre for Eastern trade, being the meeting and transhipment port between the large local trade carried in vessels of comparatively small draught and the merchant liners running between Europe and the East. Up to recent years the only accommodation for shipping was to be found in the wharves constructed by the Tanjong Pagar Dock Company. These wharves were constructed entirely of local timber, and, owing to the ravages of the Teredo and other marine pests, were in constant need of repair. Local craft used to lie out in the Singapore roads, their cargo being unloaded into lighters and native craft, either for conveyance to vessels lying at the Tanjong Pagar wharves or into the Singapore River, where they were discharged into merchants' godowns in the vicinity. In 1901, and again in 1904, Messrs. Coode, Son and Matthews (now Messrs. Coode, Matthews, Fitzmaurice and Wilson) reported to the Government of the Straits Settlements as to the best means of affording quay accommodation for dealing with local traffic, their recommendations being subsequently carried out.

The works, which are styled the Singapore Harbour Works, consist, as will be seen from the accompanying general plan, Fig. 1, of the Telok Ayer reclamation, having an area of about 65 acres in extent, a tidal basin suitable for lighters and small craft, having an area of about 21 acres with 1,900 lineal ft. of quay, and outer quays suitable for local trading craft of about 4,140 ft. in length. The works are exposed to the eastward and are therefore protected by the south mole or breakwater upwards of 4,800 ft. in length, so as to afford shelter in all weathers for vessels lying alongside the quays.

It was originally intended to provide a continuous quay along the outer or eastern face of the reclamation, but it was found, upon checking the borings originally supplied, that the depth of mud was considerably greater than had been anticipated. The design was therefore modified as above described, the centre portion of the quay where the depth of mud was greatest being omitted. Incidentally the construction of the tidal basin has the advantage of increasing the accommodation for lighters and small craft which will always be largely used in connection with the trade at Singapore.

In 1904, Messrs. Coode, Son and Matthews were requested by the Tanjong Pagar Dock Company to advise them as to the best means of reconstructing the old timber wharves and providing further accommodation, and in that year, in conjunction with Mr. Nicholson, engineer to the company, they put forward their recommendations. At that time, the total length of wharves owned by the company was about 7,500 lineal ft., of which about 2,500 ft. only had a depth alongside of 25 ft. and upwards at L.W.O.S.T. It was decided to reconstruct in a permanent manner about 4,400 lineal ft. of the old wharves, and by taking advantage of a natural lagoon at the back of the wharves, to construct a wet dock, providing a further 3,500 lineal ft. of additional quay.

The new wet dock (now called "The Empire Dock") and the reconstructed quays are clearly shown upon the plan, Fig. 1, the whole of the new quays with a total length of 9,700 ft., having a depth alongside of not less than 30 ft. at L.W.O.S.T., provision being made for giving a depth of 33 ft. if and when required.

In connection with the works at Tanjong Pagar, a new graving dock, now called "The King's Dock," was constructed in Keppel Harbour, some little distance to the westward of the "Empire

Dock," as will be seen from the plan. The overall length of this dock inside the entrance at coping level is 852 ft., the width of the entrance is 100 ft., and the depth over the cills 25 ft. at L.W.O.S.T., or 34 ft. at H.W.O.S.T. The dock can be divided by a centre caisson into two lengths of 486 ft. and 325 ft. respectively, when the caisson is in place. By placing the caisson in the outer stop the available length of the dock can be increased by 16 ft. 6 in.

In 1906 a contract was entered into between the Straits Government and Sir John Jackson, Limited, of Victoria-street, Westminster, for the construction of the works described as the Singapore Harbour works, and this contract was completed in 1915. In the year 1906 the whole of the Tanjong Pagar Dock Company's property was acquired by the Straits Government and placed under the control of the Tanjong Pagar Dock Board, Mr. J. R. Nicholson, C.M.G., Engineer to the Board, being appointed chairman and general manager. With regard to the "Empire Dock" and the reconstruction of the timber quays these works were mainly carried out by Messrs. Topham, Jones and Railton, of Great George-street, Westminster, under contract with the Tanjong Pagar Dock Board.

In 1914 the wet dock was completed and opened for traffic under the name of the "Empire Dock," and in May, 1917, the reconstruction of the old wharves was also completed, the whole of the works being opened on October 25, 1917, by His Excellency Sir Arthur Young, G.C.M.G., Governor and High Commissioner of the Federated Malay States.

Simultaneously with the carrying out of the last-named work a contract was arranged (1908), also by the Tanjong Pagar Dock Board, with Messrs. Topham, Jones and Railton, for the construction of the "King's Dock" at Keppel Harbour. This work was carried out satisfactorily from beginning to end, and was finally opened by His Excellency the Governor on August 26, 1913. Incidentally, it may be mentioned that the dock was found to be of the greatest service during the war. As already stated, the Singapore Harbour works were carried out directly by the Straits Government, being quite independent of the works carried out for the Tanjong Pagar Dock Board, but in the year 1912 the Singapore Harbour Board was constituted, and in the following year this body took over the management of the whole of the works, both at Tanjong Pagar and Singapore Harbour. All the works described both at Telok Ayer, Tanjong Pagar and Keppel Harbour are in direct communication with the Federated Malay States railway system.

The whole of the works, as outlined above, and which will now be described in detail, were carried out to the design and under the direction of Messrs. Coode, Son and Matthews and (since 1912) Messrs. Coode, Matthews, Fitzmaurice and Wilson, of Westminster. With regard to the works at Tanjong Pagar, viz., the Empire Wet Dock with the wharf reconstruction in connection therewith and the King's Dock at Keppel Harbour, Mr. J. R. Nicholson, C.M.G., engineer and general manager to the Tanjong Pagar Dock Board, and subsequently to the Singapore Harbour Board, was joint engineer with Messrs. Coode, Matthews, Fitzmaurice and Wilson.

Singapore Harbour Works—Telok Ayer Reclamation.

As already explained, these works consist of a reclamation with quays, piers and a tidal basin, together with an outer protective mole or breakwater. A general plan of the works is shown on Fig. 2, from which it will be seen that two quays are provided at the northern and southern end of the works, the southern quay being 2,500 ft. long and the northern 1,637 ft. long. The outer ends of these quays are in the form of piers, the south pier being 1,360 ft. long and the north pier 560 ft. long, having an opening 850 ft. in width between the piers, forming the entrance into the tidal basin. When the dredging is fully completed, a depth of 18 ft. will be available at L.W.O.S.T., along both the north and south outer quays, suitable for coasting steamers, the depth of water in the tidal basin being 7 ft., and therefore only available for lighters and craft of small draught. The total water area of the tidal basin is 21 acres.

SINGAPORE HARBOUR WORKS.

MESSRS. COODE, MATTHEWS, FITZMAURICE AND WILSON, MM.INST.C.E., ENGINEERS.

Fig. 2. GENERAL PLAN.

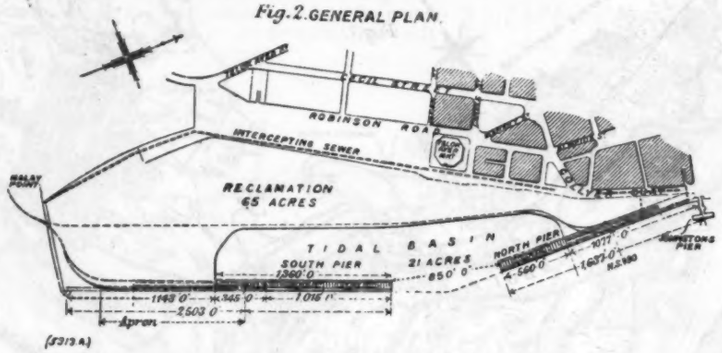
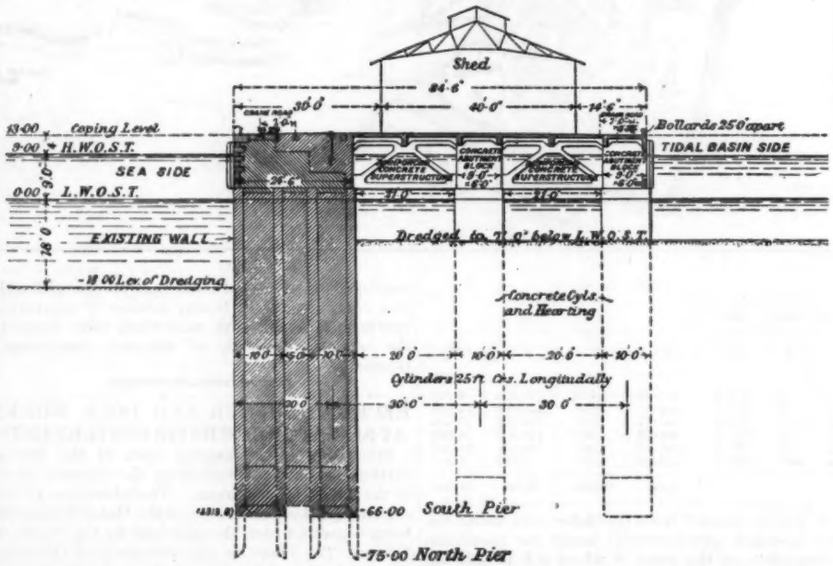


Fig. 3. CROSS SECTION OF NORTH PIER, AND OF SOUTH PIER FOR OUTER LENGTH OF 1,015 FT.



Figs. 4 to 7, page 605, give general details of the north and south quay walls, from which it will be seen that these consist of two rows of concrete cylinders 10 ft. external diameter, and 6 ft. internal diameter sunk through the soft overlying mud down to the solid clay. The cylinders consist of a series of rings laid one on the top of the other, having serrated or toothed joints, as shown on Figs. 4 and 7. The cylinder rings were pitched from a temporary timber staging driven for the purpose in advance of the work. In placing the concrete rings, a wrought-iron cylinder of a diameter slightly in excess of the rings was first placed in position, the concrete rings being lowered through this cylinder, which acted as a guide, until they rested on the surface of the mud; other rings were then superimposed, the mud being removed from the interior by means of specially arranged grabs worked by cranes from the staging. By this means the cylinders were gradually sunk until they reached the hard clay, into which they were entered for a depth of about 5 ft. During the earlier stages, the cylinders sunk of their own weight, whilst the grabbing was being carried out. At the lower depths, kentledge was required, this being placed on the top of the cylinder column in the form of cast-iron rings. In order to obtain the required final penetration, a weight of 150 tons and upwards was necessary.

As soon as the cylinders had been sunk to their required depth, they were filled up solid with concrete deposited through the water by means of specially constructed hopper boxes. The space between the two rows of cylinders was also excavated by means of a grab and filled in solid with concrete, as described for the cylinders themselves. The tops of the cylinders were braced together by rails laid diagonally, the ends being turned down into the concrete, in the manner shown on Figs. 5 and 6. Upon the foundation of cylinders thus formed a superstructure of concrete in mass, faced with granite and surmounted with a granite cope, was constructed as shown on Fig. 7.

Immediately at the back of the cylinders a mound of rubble granite was deposited, behind which selected filling, for a width of about 70 ft., was tipped, being thoroughly rammed above low-water level.

As already mentioned, the outer portions of both the north and south quays were constructed in the form of piers. A typical section of these piers is shown on Fig. 3. The outer or seaward portion consists of a sea wall, or quay, formed of concrete cylinders and mass work as already described for the quay wall. On the inner, or tidal basin, side of the pier, two rows of cylinders, 25 ft. apart longitudinally, were sunk in a similar manner to the cylinders already described. The space between the rows of cylinders and the quay wall was bridged by reinforced concrete trusses, carrying a reinforced concrete deck, the whole, with the quay wall, forming a pier, 84 ft. 6 in. wide. This work is shown in detail on Figs. 9, 10, and 11, page 606. Three sheds, 40 ft. in width, are provided on the south pier, one shed being placed upon the north pier. Crane roads and service roads are also provided, as shown.

SINGAPORE HARBOUR WORKS; CONCRETE CYLINDER WALLS.

MESSRS. COODE, MATTHEWS, FITZMAURICE AND WILSON, MM.INST.C.E., ENGINEERS.

Fig. 4. ELEVATION

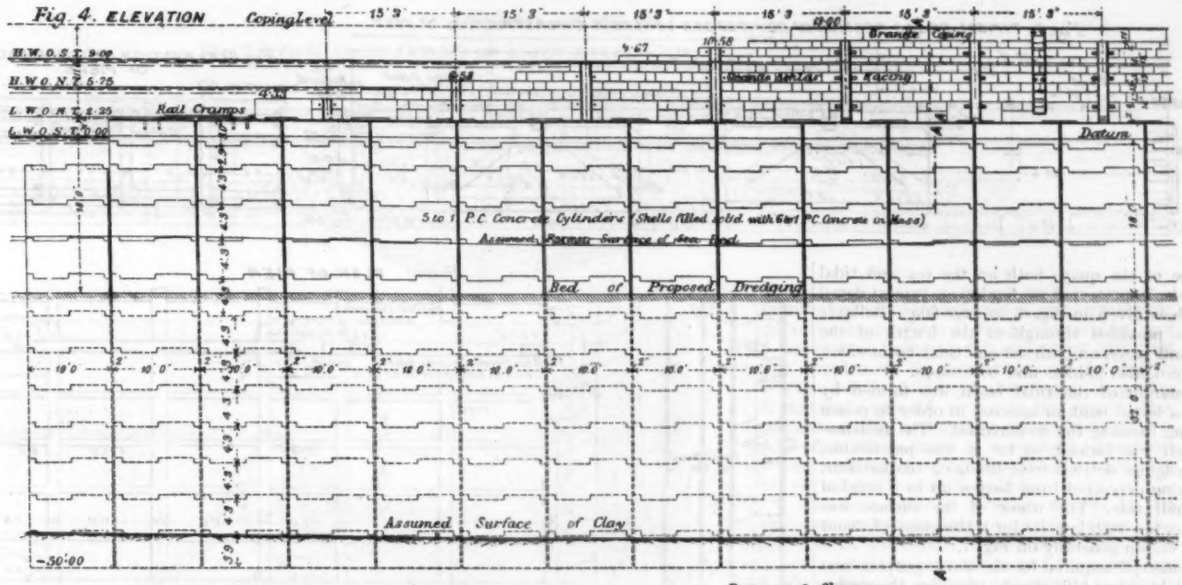


Fig. 6. DETAIL OF RAIL CRAMP BETWEEN CYLINDERS

Fig. 5. PLAN

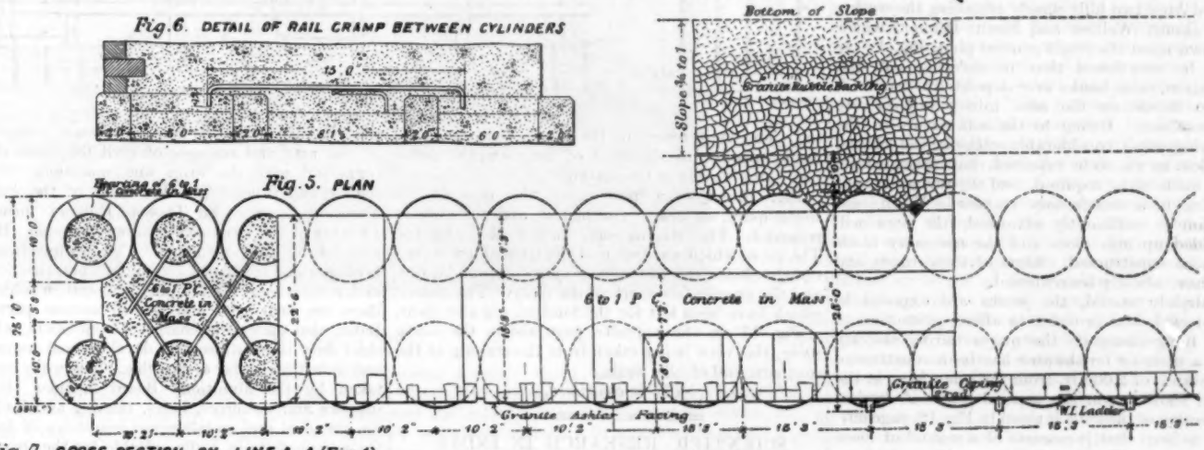


Fig. 7. CROSS SECTION ON LINE A. A. (Fig. 4)

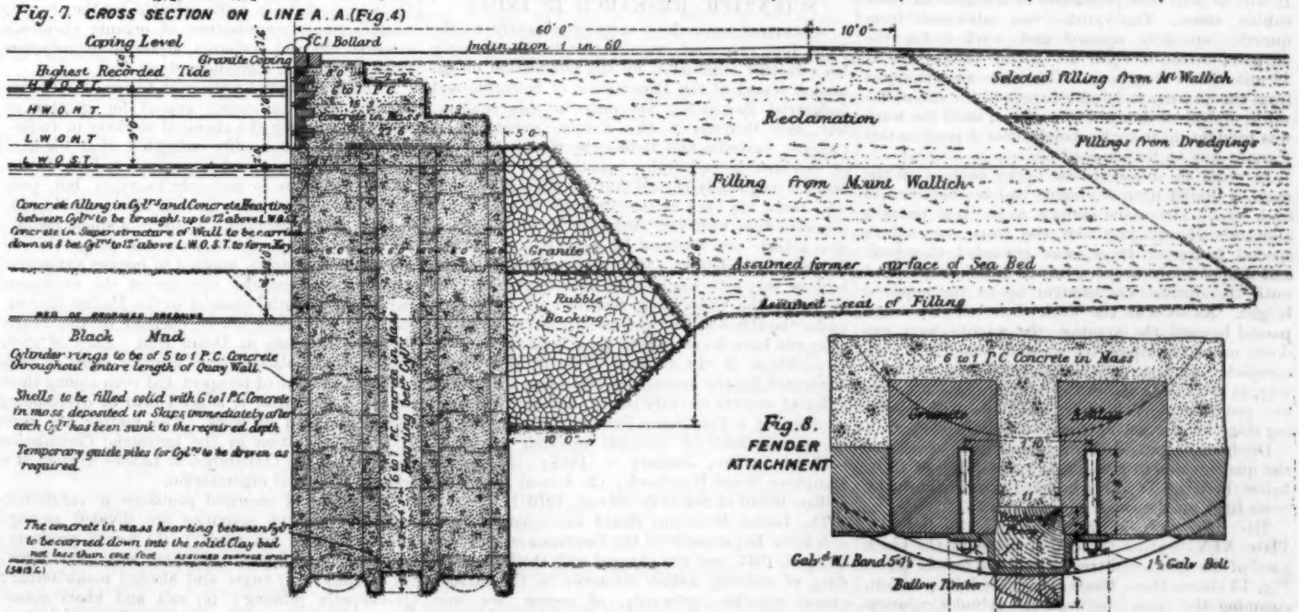

Coping Level
Granite Coping
Highest Recorded Tide
H.W.O.S.T.
H.W.O.N.T.
L.W.O.N.T.
L.W.O.S.T.
C.I. Bollard
Induration 1 in 60
Selected Filling from Mt. Wallich
Reclamation
Fillings from Dredgings
Filling from Mount Wallich
Granite
Rubble Backing
Assumed former surface of Sea Bed
Assumed seat of Filling
Concrete filling in Cyl^rs and Concrete Hearting between Cyl^rs to be brought up to 12 above L.W.O.S.T.
Concrete in Superstructure of Wall to be carried down in 6 bet. Cyl^rs to 12 above L.W.O.S.T. to form Key
Black Mud
Cylinder rungs to be of 5 to 1 P.C. Concrete throughout entire length of Quay Wall.
Shells to be filled solid with 6 to 1 P.C. Concrete in mass deposited in Skips immediately after each Cyl^r has been sunk to the required depth.
Temporary guide piles for Cyl^rs to be driven as required.
The concrete in mass hearting between Cyl^rs to be carried down into the solid Clay bed, not less than one foot
6 to 1 P.C. Concrete in Mass Hearting bet. Cyl^rs

Fig. 8. FENDER ATTACHMENT

SINGAPORE HARBOUR WORKS.

MESSRS. COODE, MATTHEWS, FITZMAURICE AND WILSON, MM.INST.C.E., ENGINEERS.

Fig. 9. TYPICAL CROSS SECTION OF REINFORCED CONCRETE SUPERSTRUCTURE OF PIER

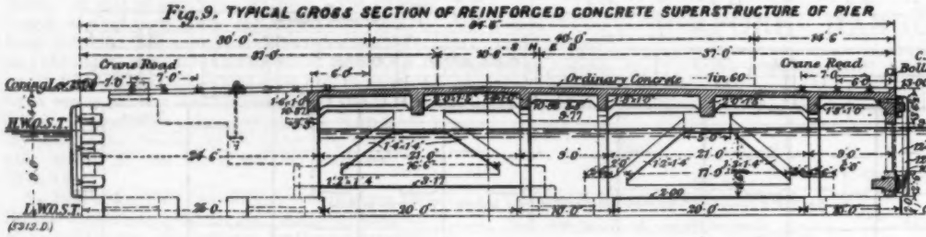
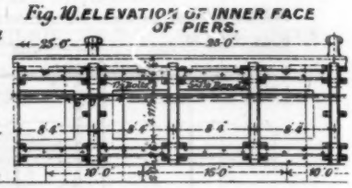


Fig. 10. ELEVATION OF INNER FACE OF PIERS.



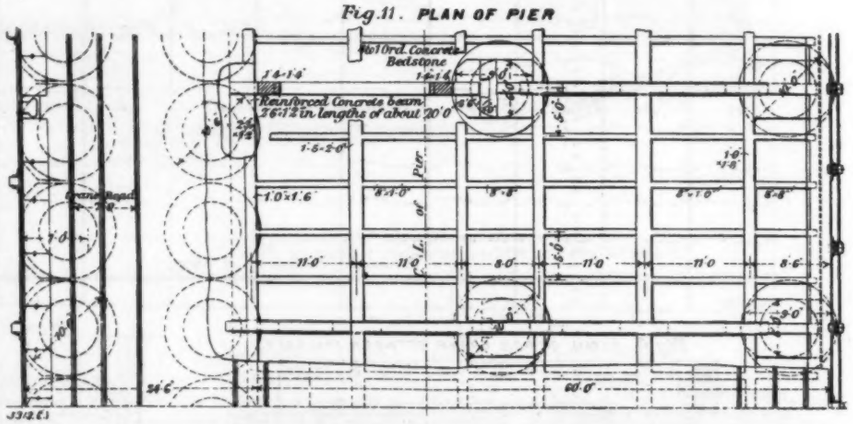


Fig. 11. PLAN OF PIER

The face of the quay, both on the sea and tidal basin side, is protected by fenders, a typical detail of which is given in Fig. 8, on page 605. Bollards are also provided throughout the length of the quays and piers, on both sea and tidal basin sides, as required, also ladders and boat steps.

The margin of the tidal basin was formed by tipping a broad bank of laterite, in order to retain the filling forming the reclamation. The reclamation itself was formed, as far as was practicable, with dredgings derived from dredging the harbour, these being deposited from barges up to a level of about half tide. The whole of the surface was finally coated with laterite for a thickness of about 7 ft., as shown generally on Fig. 7.

The material required for the above purpose was obtained from two hills closely adjoining the works, named Mount Wallich and Mount Palmer, which are shown upon the small general plan, Fig. 1. It should be mentioned that in carrying out the reclamation, cross banks were deposited as required, so as to divide up the area into comparatively small sections. Owing to the soft nature of the underlying mud, considerable settlement of the reclamation, as was to be expected, has taken place. This is made up as required, and the surface is consolidating in a satisfactory manner. When consolidation is sufficiently advanced, the area will be divided up into plots and the necessary roads and drains constructed. Some of these roads and drains have already been formed.

As already stated, the works are exposed to the eastward, and in order to afford protection to vessels lying alongside the quays during easterly winds, a mole or breakwater has been constructed at a distance of 2,000 ft. from the quay face, in the position shown upon the general plan. A typical cross-section of the mole is given in Fig. 12, page 607. It will be seen that it consists of a mound of loose rubble stone. This stone was obtained from quarries specially opened and worked for the purpose, situated upon an island distant about 22 miles from Singapore. The stone was conveyed from the quarries in hopper barges to the site of the work, and there dumped in position, until the work was brought up to such a height that deposit in this manner was no longer possible.

In order to complete the upper portion of the mole, a short length of staging had been erected at each end. The stone barges were then brought alongside the staging and the stone, carried in special boxes or trays, was unloaded therefrom and dropped into wagons, from which it was tipped until the surface was brought up to the required height. As soon as the work thus completed had passed beyond the staging, the wagons were run down on to the top of the mound, which was then completed by tipping the stone in the ordinary way, as in the case of a railway embankment. Lights are provided at each end of the mole with a landing stage for the convenience of the light-keeper.

Dredging is provided for between the mole and the quays, so as to give a minimum depth of 18 ft. below L.W.O.S.T. The dredging area is shown by cross lines on the small general plan.

The photographic views, Figs. 13 and 14, Plate XLVII, show the construction in the block yard of the reinforced trusses required for the piers. Fig. 15 shows these trusses as placed in position, spanning the spaces between the cylinder columns and ready to receive the deck as already referred to. The view refers to the north pier, the tidal basin appears on the right of the view, the south pier being visible in the distance.

Fig. 16 shows a portion of the face of the south quay, as nearly completed, and the staging removed. The staging still in use also appears. The view, which was taken at the time of low water, clearly shows the top of the cylinder foundations, and the granite face work to the quay. The chases, which have been left for the fenders, are also clear.

Fig. 17 on the opposite page shows the south mole, the view being taken from the staging at the southern end of the work.

(To be continued.)

SCIENTIFIC RESEARCH IN INDIA.

SCIENTIFIC research is very prominently to the front just now and interest therein has recently been further stimulated by the publication of the annual report of the Department of Scientific and Industrial Research. Not only in this country, but also throughout the Empire generally—in Canada, Australia and India—the vital importance of research is now fully realised. In regard to India it may safely be said that the scientific worker who turns his eyes in the direction of that great country may well feel enthusiastic, and perhaps also a little overwhelmed by its vast and, indeed, boundless possibilities. Compared with what might be done very little has hitherto been accomplished in exploring the tremendous resources of India, but under the stress of war and its imperative demands attempts have been made to get a little beyond the mere fringe of the subject. This is abundantly illustrated by the appearance of no less than three different reports recently issued, namely: (1) Proceedings of a Conference for the consideration of the organisation of chemical research in India, held at Lahore, January 8, 1918; (2) Indian Munitions Board Handbook; (3) Annual Report of Indian Board of Scientific Advice, 1916–17.

The Indian Munitions Board was constituted as a definite Department of the Government of India in April, 1917, and was charged with the important duty of utilising Indian resources to the utmost extent possible, primarily, of course, for war purposes; but such are the demands of modern war that they may be said to include practically all the arts and sciences of civil life, plus those connected with the arms and munitions of the soldier and sailor. The President of the Indian Munition Board is Sir Thomas Holland, formerly Director of the Geological Survey of India. He is assisted by four members. The organisation at headquarters consists of different branches, each under the charge of a controller, and in addition there are provincial branches in various parts of India, also under the charge of controllers, whose chief duty is to utilise and develop local resources and industries as far as possible. The work undertaken by the Munitions Board includes timber supplies and resources, hides, tanning and leather, the chemical and metallurgical industries of India, the potash salts in India suitable for the chemical manufacturer, manufacture of organic chemicals, essential oils and perfumes, glycerine manufacture, wood distillation, indigenous dyes, &c.

In his presidential address at Lahore, Sir Thomas Holland made a strong appeal for greater co-ordination among the chemical workers in India—and it will be readily admitted that chemical research is of the utmost importance in India to-day. At present there is not only isolation, but, paradoxical as it may seem there is also a considerable amount of overlapping. There is a single chemist to analyse the doubtful materials passed by the Collector of Customs, another to inspect explosives, another to assist the director of the Geological Survey, a tinctorial chemist to the Madras Government, and another lonely chemist in the Forest Research Institute at Dehra Dun. Each of these suffers from isolation, from want of *esprit de corps* and from absence of prospect, but even among these isolated units there is a good deal of overlapping and duplication of work. The matter has been under consideration by the Industrial Commission who desired the Conference at Lahore to suggest a scheme of official organisation.

The principal chemical problems in connection with Government activities are divided among: (*a*) Agriculture (oil seeds); (*b*) forest products; (*c*) drugs, perfumes, essential oils and dyes; (*d*) tanning; (*e*) sugar and alcohol manufacture; (*f*) saltpetre refining; (*g*) salt and khari manufacture; (*h*) mineralogy; (*i*) metallurgical inspec-

SINGAPORE HARBOUR WORKS.

MESSRS. COODE, MATTHEWS, FITZMAURICE AND WILSON, MM.INST.C.E., ENGINEERS.

(*For Description, see page* 603.)

Fig. 12. TYPICAL CROSS SECTION OF SOUTH MOLE.

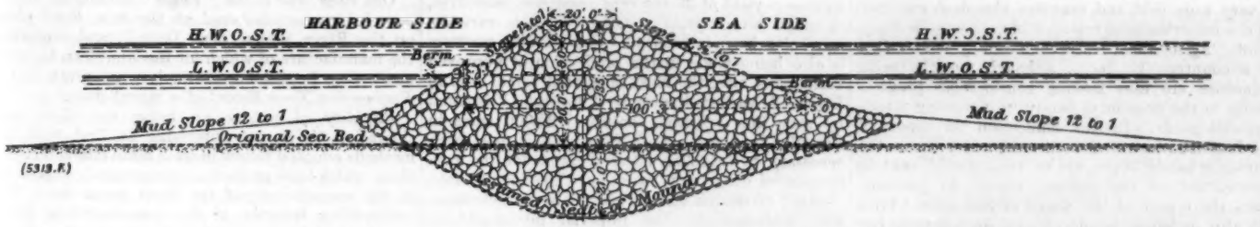


FIG. 17. SOUTH MOLE.

tion; (*j*) explosives manufacture. For administrative purposes these might be controlled in three groups: (A) Agricultural chemistry, with the chief laboratory at Pusa. (B) Organic chemistry, with two chief laboratories at Dehra Dun and Bangalore. (C) Mineral chemistry, with the chief laboratory at Kalimati or Calcutta.

Sir Thomas made one or two suggestions in regard to the necessary staff and the appointment of a chief chemist or three deputy chief chemists to the Government of India. All results of scientific and practical value would be published in the records of the Indian Chemical Department, which would be issued in three series and edited by the three deputy chiefs. Once a year the whole staff of chemists might assemble for a week's conference successively at Pusa, Dehra Dun, Bangalore and Calcutta. This conference should be attended by private chemists, including manufacturing chemists and chemical members of the Education Department. Papers read at this conference, if approved by a small committee, might be published in the records, which would thus establish at once a definite position of authority and value in scientific literature.

Such a scheme would, however, hardly be practicable in war time, but there are several matters of immediate practical interest arising out of the scheme proposed. Amongst these are: (1) Increasing the production of certain chemicals needed in the textile and other large industries; (2) assisting firms with advice and research; (3) the preparation for the medical services of drugs which could be as easily made in a laboratory as in a factory; (4) investigation of raw materials; (5) publication of results. In regard to drugs for the medical services there would probably be dozens of students willing to do this in their spare time, and the college authorities would no doubt grant the necessary facilities. In regard to the other questions, certain valuable results have already been obtained. The following table summarises Sir Thomas' account of work in hand or accomplished:—

Investigation.	*Name of Institute.*
Electrolytic preparation of white lead.	Indian Institute of Science.
Refining of waste copper.	Do.
Enzymatic hydrolysis of fats.	Do.
Utilisation of copper waste...	Patna College.
Utilisation of copper waste...	Indian Institute of Science.
Preparing soluble chromates from chrome iron ores.	Wilson College, Bombay.
Conversion of acetylene into acetaldehyde and acetic acid.	
Dyeing of skins and furs ...	Sibpur Engineering College.
Oxidation of alcohol to acetic acid.	Central College, Bangalore.
Colloidal medicinal preparations.	
Tamarind Fruit as a source of tartaric acid.	Government College,
Purification of nim and til oils.	Do.
Manufacture of citric acid ...	Khalsa College, Amritsar.
Manufacture of formaldehyde.	
Poisonous principle of ricin in castor oil cake.	
Isolation and cultivation of specific yeast associated with mahua flowers.	Wilson College, Bombay.
Efficiency of various methods of estimating sufar.	Do.
Burmese black varnish as an electrical insulator.	Rangoon College.

The difficult question was discussed as to the best means of making the results available to manufacturers and to other workers who may be following up similar lines. Some of the reports will be read to the Science Congress and afterwards published as a supplement to the Journal of the Asiatic Society; but it would be an advantage if the papers on chemical questions were kept together in some publication with a distinctly chemical flavour, a publication which would be recognised by workers in other countries to cover all that really matters in the way of chemical work in India.

A still more difficult question is that of the conditions under which advice should be given to, and research undertaken for, industrial firms. One or two suggestions were made and the possibility of official chemists acting as consultants to private firms was also considered. Another important question is whether the results of a technical investigation undertaken on behalf of, and at the expense of, a manufacturing firm should be published. Sir Thomas Holland said: "The general interests of the public and the special interests of the firm might perhaps be met by adopting a recognised interval before publication; but this course becomes in practice far less simple than it seems; for there is seldom a definite date for concluding an investigation; it always dovetails into side issues and dependent investigations. So far as I have been able to study this difficult question there appears to be a balance in favour of the conclusion that a public official should be purely a public servant; he should treat with confidence results placed at his disposal, but should be free to publish those obtained as the outcome of his researches. Ordinarily, publication is so late and is necessarily so imperfect compared with the practical points known to the firm for which the work is done, that the firm gets a sufficient start ahead of its competitors in the same line. Often they would be able to obtain patent protection for essential parts of a new method."

In considering the question of co-ordinating chemical research, it is obvious that a systematic investigation of Indian raw materials, especially vegetable products, is about the most urgent. In spite of the valuable results obtained at Dehra Dun, at the Indian Institute of Science, at the Imperial Institute in London, and in various Indian colleges, comparatively little has been so far accomplished. For this work the chemist requires the co-operation of the Departments of Agriculture, Forests and Botany. It thus appears desirable to organise the chemical fraternity for representation on the Board of Scientific Advice.

Co-ordination is indeed of fundamental importance in research. No department can be entirely watertight and isolated. This particularly applies to such fields of research as agriculture and forestry, which are among the most important in India. The engineer, the chemist, the botanist, entomologist and geologist will have to co-operate in the solution of many problems which refuse to be solved by approach from one point of view only. It was early recognised in India that there were several isolated scientific departments and that there ought to be one central authority to allocate research work to the best advantage, to watch progress to co-ordinate results, and especially to ensure a continuity of policy. The Indian Board of Scientific Advice was accordingly established in 1902. This

Board meets twice a year and discusses the departmental programmes of research submitted for its approval. The latest annual report of the Board (1916–17), naturally suffers somewhat in bulk owing to the special circumstances of the times and the absence from India of many scientific workers on military service. Nevertheless the report covers a very wide field and provides abundant evidence of the importance of research in economic development. Agricultural research naturally comes first in a country like India, although manufacturing industries are also making considerable progress owing to the present difficulty in importing manufactured goods. In this connection the report of the Indian Industrial Commission, which was in the printer's hands some weeks ago, should contain information of the utmost value. In previous years the report of the Board of Scientific Advice has also included details of seed distribution, but these details are now relegated to the report on the Progress of Agriculture in India, issued by the Agricultural Department (Calcutta, Superintendent Government Printing, 1918), in order to avoid duplication. This section of the report under review was strictly limited to the scientific papers and the application of botanical science to agriculture. Of these the chief are: (1) Dealing with the classification of the wheats of Baluchistan, Khorasan and the Kurram; and (2) Treating of the requirements of the roots of the cotton plant in the Central Provinces. Experiments show that very good crops of cotton can be grown even if the rainfall is over 50 in., provided that the soil is well drained and aerated. It has hitherto been held that cotton would not grow where the rainfall is over 45 in. Obviously it depends largely on soil drainage and aeration, and although these experiments in the Central Provinces are distinctly interesting and perhaps indicate an additional field for the application of "dynamite" cultivation, it cannot be said that they led to any very great discovery. As a matter of fact the Indian cotton crop is practically at the mercy of the monsoon, and the varieties which thrive best are surface rooted. Subsoil drainage and aeration would naturally prove very beneficial. The advantages of deep cultivation by means of dynamite have not yet been fully realised generally.

Scientific plant breeding of the kind instituted in Pusa and elsewhere is another field of research of enthralling interest and boundless possibilities. Twenty million acres of cotton are now grown in India. An improved variety at Surat gave a premium value of 13 per cent., and in Sind new varieties are giving a premium of 23 per cent. In the Central Provinces a new introduction covering 800,000 acres is estimated to have brought the cultivators increased profits of nearly 900,000*l*. Notwithstanding these increased profits the native cultivators are very conservative and do not always take kindly to new varieties. The following is a good example of the methods adopted to impress the ryot's oriental imagination. "In the Tinnevelly district the department had to resort to drastic action for the control of seed in the case of some 90 acres of pulichai (the inferior cotton) . . . the seed from this cotton was publicly burnt . . . before a large gathering of ryots."

The advantages to be derived from the application of the principles of scientific plant breeding by selection, &c., to the cultivation of the vegetable products of the British Empire are incalculable. Take the case of vegetable oils for example—one of the most important of our Empire's vegetable products. By means of scientific plant breeding not only could the amount of seed or fruit be increased, but also the percentage of the desired constituent, in this case vegetable oil. A great deal of valuable work in this direction is being done in the United States with the cotton plant, and the same could be done in India. Indian linseed, as is well known, contains less oil than Egyptian or Argentine linseed, and the reasons for this should be investigated with a view to improving both the yield of seed and the percentage of oil. In most cases improvement in one part of the plant is correlated with improvements in other parts; that is to say, with cotton and linseed for example, the oil-bearing parts of the plant can be improved without detriment to the fibrous or textile parts, in fact, the latter would probably be improved at the same time.

Astonishing results have been obtained at Pusa with wheat, of which 30,000,000 acres are grown in India. The now famous "Pusa No. 12" grown on 100,000 acres in the United Provinces gave an increased yield of 25 per cent., and was, moreover, of much better quality. Other valuable varieties have also been introduced. Considerable progress is also being made in the production of improved varieties of rice, the most important cereal crop in India. A variety known as "Indrasail," isolated by pure line selection, occupied 20,000 acres in Bengal. In the Central Provinces it has been necessary to establish 30 seed farms for the production of other new varieties. The inquiry into "ufra" of rice, a disease caused by an eel-worm, was continued by the Imperial mycologist in collaboration with officers of the Bengal Agricultural Department, and many points regarding the parasitism of this worm, which had hitherto been obscure, were cleared up. The investigation has now reached an advanced stage, and further experiments are being undertaken to evolve practical remedial measures.

In the improvement of jute (of which India exports annually products worth 40,000,000*l*.) some notable advances have been made. It is expected that in the present year more than 30,000 acres will be sown with a new selected variety, of which 500,000 packets of seed have been distributed. In this connection a valuable scientific discovery may be mentioned. The pernicious weed, water-hyacinth, which infests the waterways of Bengal, has been found to have a high potash content, and is consequently a valuable manure for jute, the use of which not only directly stimulates yield, but also protects the plant against a Rhizoctonia disease which attacks it.

Of particular importance at the present moment is the work being carried out on indigo, and further investigation has confirmed the theory that bacterial action plays a large part in indigo manufacture. Various factors have been discovered to account for the failure in factory practice to obtain nearer approximation to the theoretic yield of indigo from the plant. The war has naturally caused a great revival of interest in indigo, and the Behar planters and the Indian Government in co-operation with a strong scientific and business committee in England, are taking vigorous measures to increase the output of indigo per acre and to place on the market a standardised paste.

In his interesting address at the British Scientific Products Exhibition, Mr. D. T. Chadwick, the Indian Trade Commissioner, showed very clearly that the progress of Indian industry and its economic development generally depended very largely on chemical research, using the term in its wider sense to include agricultural chemistry and electro-chemistry, this latter being closely connected with the utilisation of India's enormous reserves of water power. And, finally, in the Chelmsford–Montagu Report it is pointed out that the policy of appointing scientific officers to the agricultural services has been attended with a measure of financial success which certainly suggests that opportunities have been lost in other industries. "We are advised, for instance, that tanning, glass-making, soap-making, sugar refining, and the manufacture of a great variety of vegetable dyes, &c., . . . present obvious opportunities for the application of technical science." The Industrial Commission has not yet issued its report, but "we understand that it is likely to lay stress on a substantial increase in the scientific and technical services of the country and their organisation under a separate department of the Government of India."

THE BUILDING OF AMERICAN SUBMARINE CHASERS.

The development of anti-submarine warfare has been the occasion for the introduction of many new forms of offensive weapons, and has in particular necessitated the construction of an immense fleet of high-speed vessels of relatively small dimensions ranging from sea-going torpedo-boat destroyers of about 300 ft. in length and upwards of 40 knots speed to small high-powered motor launches for coastal services. Between these limits are several types of small patrol vessels specially designed for anti-submarine service, and in the design and construction of which America has taken a prominent part.

One such type is the "Eagle" submarine chaser now being manufactured at the new Ford plant on the River Rouge, near Detroit, and regarding the manufacture of which for the American Government some interesting particulars are given in the *Engineering News Record* of a recent date.

Rapidity of production being the chief consideration, it is not surprising to find that the methods adopted follow in their main characteristics those which have proved so conspicuously successful in the manufacture of the Ford motor car. The outstanding features of the manufacturing plant are (1) straight line motion of constituent parts of hull and machinery to vessel under construction, (2) novel launching arrangements, and (3) straight line movement of vessel during building, launching and completion operations through the hands of successive groups of workers, the whole contributing to speed of construction by the elimination of all superfluous handling of material and loss of time due to workers constantly having to move from place to place in accordance with the progress of the work.

The design of vessel was evolved by the Navy Department with the object of assisting manufacture to the maximum extent possible, and to that end some interesting departures from recognised practice have been made. Straight lines have been substituted for curves to the utmost possible extent, both in longitudinal and transverse sections, thus simplifying the hull form. Shell and other plating is arranged as far as possible in parallel strakes, thus utilising to the utmost the multiple punch. Transverse framing is composed entirely of straight flanged plates and angles as shown in Fig. 1, page 609, a form of construction which will be seen to lend itself admirably to rapidity and accuracy of manufacture. By using flanged plate frames in place of the usual rolled channel or other section much of the difficulty experienced in the bevelling of such sections required in the fore and after bodies is eliminated, while the individual units of the completed frame obviously lend themselves to power press manufacture.

The lay-out of the plant and the specialised subdivision of the building operations are of especial interest as a concrete example of the successful adoption of American factory methods to shipbuilding, and the employment of unskilled labour in the production of the component parts of a complicated whole. The plant is situated on the bank of the River Rouge, and is so laid out that all movement from the delivery of raw material to the completion of the vessel takes place in a general direction parallel to the river. All the operations take place under cover, and the sequence is as follows: (*a*) Raw material received; (*b*) marking and punching of material; (*c*) assembling and riveting of parts such as frames, bulkheads, &c., which are to be erected as completed units; (*d*) erection of hulls and completion ready for (*e*) launch: (*f*) shipping of machinery and completion of outfit.

Material as completed at (*b*) and (*c*) is transported by overhead cranes to its appropriate position in the hull-erecting department. The hull erecting department (see Fig. 2) comprises 21 berths arranged in three lines parallel to the river, and having spaces between the lines for the storage of the parts to be erected. Erection and completion for launching takes place in seven stages, the hull moving forward one hull length on the completion of each stage, so that the workers in each section of the erecting shed are constantly employed on the same job on each succeeding hull. This specialisation naturally makes for speed and accuracy, obviates unnecessary movement and congestion of men, and ensures the minimum transport and handling of material. On completion of hull assembly the vessel arrives at the launching berth, and is transferred a short lateral distance to the launching platform. This latter is of somewhat novel design, and consists essentially of a 200-ft. railroad bridge mounted on

hydraulic jacks capable of moving it up and down through a range of 20 ft. By means of this device (see Fig. 3) the vessels are lowered into the water to receive machinery and complete fitting out. During the process of fitting out the same straight line motion of the vessel to meet the successive squads of operatives and items of outfit which distinguish the building stage is continued until the vessel is finally completed.

The whole scheme of building operations—including the hull design—is obviously conceived and carried out entirely from a factory manufacturing point of view, and naturally differs in practically all respects from ordinary shipyard practice. The straight-line motion of the job to the material and to the workers is a theoretically perfect conception which has apparently come well out of the test of practical application, thus justifying the application of factory methods to the solution of this particular problem.

Whether any or all of the methods described are applicable to the ordinary business of shipbuilding, and if so to what extent, are questions which should receive the serious consideration of shipbuilders, more particularly in the light of the present urgent demand for new tonnage and the prevalence of standard types of vessel. The straight-line movement of the vessel through a series of stages in building, which is a most important part of the Ford system, is not readily applicable to existing shipbuilding plants nor is the movement of large-sized vessels a simple matter. It may be taken for granted that any adoption of the system on a large scale could only be considered where the vessels to be built were of a standard design and where the certainty of repeat orders would guarantee continuity of work. Considerations of space forbid the longitudinal movement of large vessels in practically all existing shipyards, while the mechanical problem of shifting a mass growing in weight to, say, 5,000 tons, is one which would call for the installation of powerful plant.

Whether a scheme of transverse movements could be incorporated in the lay-out of a new shipyard building standard vessels might be worth considering, but the arrangement of uprights and staging, crane services, &c., suggest practical difficulties and high on-cost charges in keeping with the larger units operated.

The system of assembling and completing on the ground units of the largest practical dimensions and erecting these in the ship in a completed state has already been very largely adopted in the shipyards. The straight-line form of hull has already been adopted for certain standard vessels, and was described and illustrated in these pages some time ago. The simplification of frame girder suggested by the adoption of pressed steel component parts is more apparent where the units dealt with are light in scantling, and it is doubtful if any advantage would be gained by its adoption in the construction of heavy frames even in those yards where the plate flanging machinery is adequate for the work. While many of the Ford factory methods are of doubtful application to ordinary shipyard work, there is no doubt that the specialisation of men on certain classes of work, methods of precision adopted, and straight-line motion of all material provide ample scope for thought to all shipbuilders, and especially to those charged with the tasks of laying out new plant or increasing the efficiency of plant already in operation.

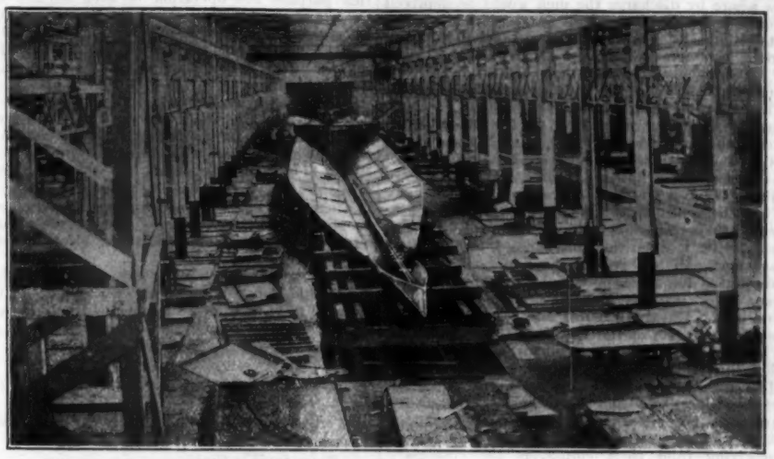


FIG. 2. HULL ERECTING DEPARTMENT.

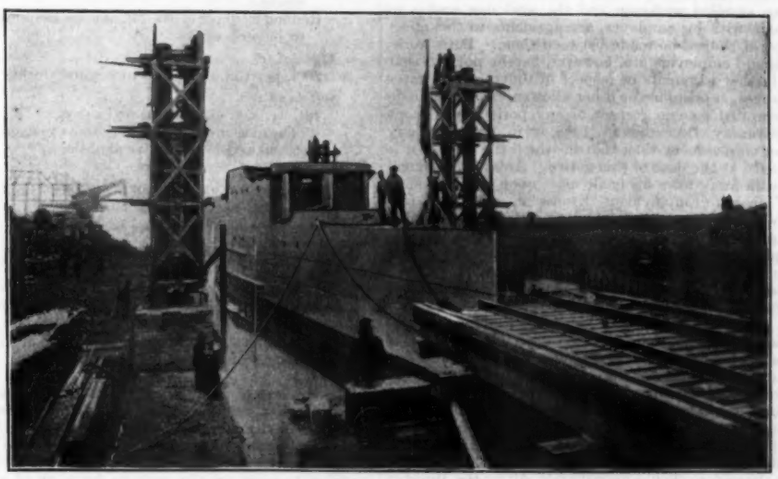


FIG. 3. VESSEL FLOATED READY TO RECEIVE MACHINERY.

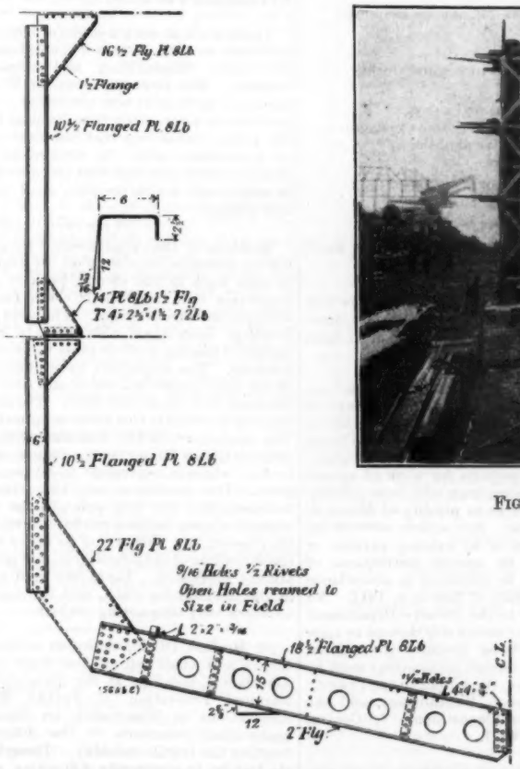


Fig. 1. FRAME OF FLANGED-PLATE MEMBERS IN STRAIGHT SECTIONS

INDUSTRIAL NOTES.

THE Labour Research Department Conference on International Labour Legislation and the Peace Treaty, which was fixed for November 30, has been postponed owing to the General Election. It will be held on Saturday, January 25, at 3 p.m., at 25, Tothill-street, Westminster, S.W. 1.

The following statement is made for the information of employers and men alike regarding men employed as assigned Army Reserve Munition Workers and of soldiers released from the Colours under the conditions of Army Council Instruction 344 of 1916. All men who have served with His Majesty's Forces must communicate their present and permanent address to their Record Office.

Soldiers released from the Colours under the conditions of Army Council Instruction 344 of 1916 and Army Reserve Munition Workers with the exception of those in Class P, Army Reserve, who are serving on a normal engagement and have a further liability to serve with the Colours, will be given a month's furlough by the Officer i/c Records, who will also forward to them instructions where to rejoin.

Soldiers released from the Colours under the conditions of Army Council Instruction 344 of 1916 and

Army Reserve Munition Workers: (1) Who are serving on a duration of the war engagement, or (2) who are serving on a normal engagement whose full period of colour service has expired, or (3) who are in Class P. Army Reserve, will be discharged, but in individual cases where by discharge the men would be deprived of long-service pension rights or reserve pay, such rights will be safeguarded. Army Reserve Munition Workers who were attested and deemed to be enlisted, but have never served with the Colours and are at present in Class W. of the Reserve, will be relegated to Class B of the Reserve.

Such discharges, relegations to the Reserve, or return to the Colours will have effect from December 14, 1918, and any payment or allowance due to the men will be forwarded in due course. Army Reserve Munition Workers who have served in the Royal Navy and have been demobilised, should forward the service papers in their possession to the Admiralty, Whitehall, London, S.W. 1, when their discharge, if on hostilities engagements only, will be carried out, and any payment or allowance due to them will be forwarded in due course. Army Reserve Munitions Workers who have served in the Royal Air Force and are at present in Class F. or F. (P.) of the Royal Air Force Reserve, will be discharged, and any payment or allowance due to them will be forwarded in due course.

Men who enrolled as Army Reserve Munition Workers are now free from the obligation which they contracted when they enrolled, and may leave the work to which they have been assigned on giving to or receiving from their employers the customary trade notice in just the same way as any ordinary workman, subject to the provisions of the Munitions of War Act, 1917.

Where an employer wishes to retain the services of an enrolled workman and the workman wishes to remain with his employer, arrangements to this effect may, of course, be made between them. Both workmen and employers are, however, hereby notified that no further payments in respect of differences of rates of wages, subsistence or other allowances can be made to enrolled men in respect of any period subsequent to Saturday, December 14, 1918, or in respect of any other employment than that in which the workman is engaged at the date of this notice. Any man assigned to work away from his home may, upon application to the nearest Employment Exchange, receive a free railway warrant to take him to the railway station nearest to his home or should he have obtained other employment elsewhere a free railway warrant to that employment.

Soldiers released from the Colours for civil employment under the conditions of Army Council Instruction 344 of 1916 will cease to be employed under the conditions of Army Council Instruction 344 of 1916 as from December 14, 1916, the date on which their discharge relegation to the Reserve or return to the Colours will take effect. Soldiers who are desirous of leaving their present employment on the above date should immediately give notice to their employers of their intention to do so. Employers who are desirous of dispensing with the services of these soldiers before the above date should immediately advise the Ministry of Munitions, Release from Colours Section, 6, Whitehall Gardens, London, S.W. 1, and state whether the soldier has, or has not, other employment to which he can proceed. If he has employment to which he can proceed, the name and address of the new employer should be given. These soldiers will continue to be employed under the conditions of Army Council Instruction 344 of 1916 until their discharge from the Army, relegation to the Reserve, or return to the Colours takes effect, namely, December 14, 1918, and they must remain in their present employment until that date unless their transfer to other employment has been authorised by the Ministry of Munitions, Release from Colours Section, meanwhile. Any soldier assigned to work away from his home may upon application to the nearest Employment Exchange receive a free railway warrant to take him to the railway station nearest to his home or should he have obtained other employment elsewhere, a free railway warrant to that employment.

The Minister of Munitions announces that restrictions upon the release of new machine tools and wood-working machinery have been removed, provided such machines are purchased from firms or persons holding permits from the Minister to trade in such articles. It is consequently no longer necessary for persons or firms desirous of purchasing such machines to make application to the Ministry of Munitions for release certificates before placing their orders with the manufacturer or merchant, as the case may be. It should be pointed out that the restrictions upon the purchase or sale of second-hand machine tools and wood-working machinery have previously been removed.

The Minister of Munitions announces that until further notice manufacturers of forgings, stampings and castings, in iron, steel or malleable iron, are at liberty to accept orders for such forgings, stampings and castings for priority below Class B., subject only to the Order as to priority dated March 8, 1917. For this purpose the operation of such clauses of the Control of Steel Supplies Order of November 20, 1916 (as amended by the Order of December 14, 1917) as prohibit the manufacture of iron, steel and malleable iron for orders ranking below Class B. is suspended.

The Minister of Munitions gives notice that H.M. Government is prepared until such time as the existing Orders issued under the Defence of the Realm Act are withdrawn, to release without special priority permits, stocks of non-ferrous metals, in so far as they are available, for general industrial purposes. Applications in connection with the release of such materials should be made to the Controller of Non-Ferrous Materials Supply, Ministry of Munitions, Hotel Victoria, Northumberland-avenue, W.C. 2.

Licences will, when necessary, be granted by the War Trade Department for the export of goods manufactured from non-ferrous metals, as freely as possible to all destinations unaffected by the blockade.

Present Schedule of Prices.

Copper—
Electrolytic, 137*l.* per ton delivered to buyers' works.
Best select, 135*l.* per ton delivered to buyers' works.

Brass Ingot to Government Specification—
93*l.* per ton delivered to buyers' works.

Spelter—
G.O.B., 57*l.* per ton delivered to buyers' works.
Refined 99·9 per cent., 75*l.* per ton, delivered to buyers' works.

Aluminium—
200*l.* per ton, delivered to buyers' works.

Soft Lead—
40*l.* per ton ex-steamer or ex-store.
(The existing schedule in relation to manufactured articles in lead is abolished.)

Nickel—
195*l.* per ton ex-works or warehouse.

Antimony—
80*l.* per ton ex-works or warehouse.

These prices are subject to usual extras for small parcels.

The Minister of Munitions reminds all buyers and sellers of iron and steel that the current maximum prices for home sales of iron and steel remain in force until a further announcement is made.

The Minister of Munitions gives notice that as from this date no permit is required from the Ministry of Munitions or any other department for the manufacture or sale of iron and steel wire or wire ropes for the home trade. The Government will, where necessity arises, continue to issue priority permits for work of special national importance, and firms may still issue priority certificates where the order as to priority of March 8, 1917, allows them to do so. Any orders covered by such permits or certificates or by existing permits or certificates not cancelled by specific instructions of the Government will still be executed in accordance with the Order as to priority of March 8, 1917. No applications need be made to the Priority Department of the Ministry of Munitions unless it is desired to raise the priority of a contract on grounds of national importance. Colonial and foreign applications must be put forward in the usual way, the former to the Priority Department, 1, Caxton-street, Westminster, and the latter to the War Trade Department, 4, Central Buildings, Westminster, S.W. 1.

The Minister of Munitions announces that contractors in possession of plant and machinery owned by the Ministry of Munitions who wish to utilise such plant and machinery for civil work may do so provided they notify the superintendent engineer in their Area within one week from the date upon which the plant and machinery was first used for purposes other than those for which it was provided. The utilisation of such plant and machinery will impose no obligation upon the contractor to purchase or the Ministry to sell, although should a sale not be effected to the contractor he will be required to pay a reasonable hire, which, unless an agreement exists to the contrary, will in no case exceed the rate of 20 per cent. per annum upon the cost price of the machine, and also to release the machine when required to do so by the Minister.

The first meeting of the Joint Industrial Council for the saw-milling industry was held at the Ministry of Labour on Thursday, November 21. This is the nineteenth Joint Industrial Council to be formed, the others being Pottery; Building; Rubber; Gold, Silver, &c.; Matches; Silk; Furniture; Chemicals; Baking; Vehicle Building; China Clay; Hosiery; Paint and Varnish; Bobbins; Leather Goods; Bedsteads; Hosiery (Scottish Section); and Woollen and Worsted (Scottish Section).

A ballot is being taken this week in the engineering and shipbuilding trades of Great Britain. The employers have offered a 47-hour week without any reduction in wages as against the present 53 hours. The men's leaders recommend its acceptance. About 3,000,000 skilled workers will be affected. The negotiations were commenced in 1913, but have been held up during the war. At the last meeting of the parties the union representatives claimed a 44-hour week. The employers in their reply stated that the sudden cessation of hostilities called for a readjustment in the working conditions, and, as stated above, replied with the offer of 47 hours per week. The joint executive thereupon passed a resolution that the 47-hour week and conditions constituted a reasonable attempt to readjust the working conditions in the shipbuilding and engineering trades, and recommend their acceptance to the members of all the unions concerned.

A uniform ballot paper is being sent out for and against the acceptance of the offer. The papers must all be returned by December 16, and in the event of a favourable reply the new scale will come into operation on January 1, 1919. The change will mean a reduction of 6 hours per week in the Manchester area and 7 hours in the Scottish and London provinces. Under the new scheme there will be only one break for meals, and the hours suggested are 7.30 to 5 for five days and 7.30 to 12 on the Saturday, or, as an alternative, 8 to 5.30 and 8 to 12.30.

There was last week a strike of boilermakers, riveters and other men on piece work, employed at the yard of the Goole Shipbuilding and Repairing Company, Limited. The men came out on Wednesday and on Saturday agreement was arrived at. The dispute was in reference to proposed time-keeping for piece workers, the latter contending that the new proposal was not in accordance with the recognised custom of the district, which provided that piece work, where lighting arrangements are impossible, shall be between dawn and twilight.

Members of the Amalgamated Society of Operative Cotton Spinners have decided, by 10,132 votes to 424, to stop work in the second week in December if the employers still resist their claim for a 40 per cent. advance on current wages. The vote of the Cardroom Workers' Association also shows a large majority in favour of ceasing work to press their claim for a similar advance. The employers have offered an advance of 40 per cent. on pre-war rates, and they say they are not prepared to increase that offer. The number of workers directly involved in this strike is approximately 100,000. The operatives on the manufacturing side of the industry claim a 50 per cent. advance on the wages paid to-day, which is equivalent to 80 per cent. on pre-war rates. The employers say this claim is altogether unreasonable, and they point to the state of trade in support of their decision not to entertain it. Merchants, they assert, are now trying to make arrangements for the cancelling of cloth contracts, and prospects generally are not promising. There has been a great falling-off in the demand for cloth, and the trade has suddenly to face a very disquieting outlook.

Sir Herbert Dixon, chairman of the Cotton Control Board and chairman of the Fine Cotton Spinners' Association, speaking at the inaugural meeting of the National Federation of Textile Works Managers' Associations in Manchester, on Saturday afternoon, made some comments on the difficulties now confronting the textile industry. Though, he said, it was the fashion to exaggerate difficulties, we must not hide from ourselves the fact that grave problems had been created, very largely, by the war. Demobilisation did not affect the cotton trade as it did the iron and munition industries. A more serious question was the sale of war material. He knew there was a terrific quantity of war material which would come into the market, and it was the duty of the Government to sell it with the least possible damage to the trading industries of the country. About a third of the textile industry was employed upon war work, so that the material for sale contained a large number of textile products. All that Government trade would soon be cut off, and in the next few weeks they would be faced with greatly reduced orders. The Government was fully aware of the danger, and would do everything in its power to minimise it.

The Ministry of Reconstruction has issued a leaflet showing what has been done to utilise workshops

which were set up for war purposes and to utilise the labour which was employed in them. A committee, with Mr. H. D. McLaren, M.P., as chairman, has been appointed to compile a list of the articles suitable for manufacture by those with engineering trade experience or plant, which were either not made in the United Kingdom before the war but were imported, or were made in the United Kingdom in small or insufficient quantities, and for which there is likely to be a considerable demand after the war, classified as to whether they are capable of being made by women, men and women, and skilled men, and setting out the industries to which such new manufactures would most suitably be attached. The committee has not yet fully reported, but has agreed that some of the information acquired in the course of its investigations should be made public in this pamphlet. Fifteen branch committees have been found to be necessary up to the present. These have dealt with wire machinery, printing machinery, printer's general machinery, paper-making machinery, leather manufacturing machinery, textile machinery, light section rolling and drawing, agricultural machinery, aircraft, hollow-ware and pressed work, electrical apparatus, scientific instruments, miscellaneous machinery, machine tools, and the motor industry. The pamphlet gives information as to the position in regard to these things.

A special conference of the Miners' Federation of Great Britain was held at Southport on November 26, to determine proposals for a further substantial increase in wage, and a uniform shorter working time for surface workers at the collieries. The present rate of wages in the coal-mining industry is the highest which has ever been paid. The demand for this latest advance was made at the Scottish miners' annual conference, when a resolution was passed that a further application be made for a 50 per cent. advance on present rates. This proposal came before a recent conference of the Miners' Federation of Great Britain, when a resolution was passed in favour of "a substantial advance in wages," and the executive were instructed to prepare a return of selling prices of coal in the various districts and present proposals for what they consider should be the amount of the advance to be asked for. In several districts there have recently been agitations for a shorter working day for colliery mechanics and for all surface workers. The Coal Controller has offered the federation, on behalf of the Government, legislation within six months of the end of the war, limiting the working time to 8½ hours, less 20 minutes for a meal, conditional on present working time in the various mining districts remaining undisturbed during the war period. The federation has decided in favour of immediately putting this working time into operation in all the federation districts, and reports will be received by the conference as to the action taken in the various districts to enforce this. The after-war policy of the federation as to working hours is an all-round 6-hours day for every person employed in and about the mines.

"THE STRENGTH OF ROTATING DISCS."

To the Editor of Engineering."

SIR,—I wish to state that the method of calculating the strength of rotating discs dealt with in an article of mine which you published in your issue of August 9 last (page 131) is based on the work of Herr Donath, a Dresden engineer, who treated the subject in a pamphlet entitled "*Die Beirechnung rotierenden Scheiben und Ringe*," published by Julius Springer, Berlin, in 1912. The curves given in Fig. 1, page 131, are derived from Herr Donath's pamphlet, but the scales give stresses in pounds per square inch and velocities in feet instead of metric measurements and metres per second, as in the originals. The diagrams, Figs. 2 and 3, are also Herr Donath's. I regret that, owing to a misunderstanding, these acknowledgments of my indebtedness to Herr Donath were not made in my article.

I am, yours truly,

A. HAERLE.

Ipswich, November 27, 1918.

DUTIES OF FOREMEN, SENIOR AND JUNIOR.

To the Editor of Engineering.

SIR,—Foremen in all classes of business life, are no doubt the most criticised class, both in print and out of print. The simple reason being, of course, that they are, of necessity, always in close contact with organised "human element," which especially at the present period, is a most forceful element, and in the very near future will be more pronounced still.

Foremen have to deal daily with all classes and types of men politically, religiously, morally and intellectually; all these things should be noted and acted upon, tactfully and judiciously handled, to obtain good results, both as regards output and a smooth, amicable working with every individual connected with the department.

My experience and policy in this matter is to be as affable with the men as is consistent with the discipline of the shop, both in the shop and out of it.

To obtain good results from the men you must get their respect and sympathy, and, naturally, in turn have a sympathetic interest in the men. Such a policy as this promotes a progressive and happier relation between the men and masters, as well as a tendency to build up a better understanding and a good foundation for the coming inevitable trade war, which will be a vital matter for our country and posterity. That great "iceberg" which has stood between Capital and Labour for so long must be removed, in the welfare of all.

I would advise all young foremen to study individuals and, by so doing, they will gradually find that you cannot deal with all men alike. The method you adopt in one case does not necessarily apply in another case with similar results. Studying human nature is not an irksome task, by any means; first of all find out your own little weaknesses and faults and, if possible, set them right; this will give you an unbiassed outlook to the failings of others.

When on holiday, say, at Blackpool, or some large town where you are sure to find a mixed or cosmopolitan crowd, take some spot where you can conveniently watch, for an hour, the crowd as it files past and note the different and varying classes and types of people. Observation and, to a marked degree, instinct, will all but label the very nature of your fellow man. It is a beautiful and most interesting study.

To recommend a man for the position of a foreman is a most important matter. He must primarily be an intelligent workman and, quite as important, or even more so, is the knowledge and tact of the art of dealing humanly with those placed under his control. And, again, he must have a strong will in a strong and robust body. A strong and straightforward man always commands more respect than a man, more or less of "jellyfish type."

It is essential that a foreman, when walking through his department following up the progress of the work in hand and dealing with dozens of men and matter daily and open to the criticism and comments of both managers and men, some kind, others not flattering, should possess a good nerve and have the utmost confidence in himself. I have seen young foremen get quite nonplussed before they have walked many yards down the shop, by the apparently hostile demeanour of some man or other they have come in contact with. A lack of confidence in themselves is simply the cause for this floundering, whereas a little tact distilled with a little encouragement and straight talk would have put the matter right.

I again repeat that much care and thought should be exercised when appointing a foreman, the position being both difficult and exacting, especially in these days, and for some future time. The appointment of an unsuitable man may be fraught with disaster both to his firm and to himself.

Another matter of import is that the foreman's salary should be such as will enable him to maintain a status consistent with his position, both inside and outside of the workshops. Foremen, as a body, outside the workshop, are looked upon as being the occupiers of good financial positions, which in 95 per cent. of cases is entirely erroneous, and most embarrassing to the foreman's dignity in more ways than one.

I know not a few men who would make good foremen, but who would not take a foremanship on account of the comparatively meagre salary attached to such. These men prefer to seek office with their respective "trades unions." These men consequently are diverted from the useful position they would have taken, and of course this means, unfortunately, a loss of good men to the trade concerned.

The "trades unions" now have a considerably extended opening for berths to be filled by smart members of their unions, such as district committees, combined committees, shop stewards, organising delegates, &c. All of which offices have remuneration attached to them, and all of which are honourable positions.

Yours respectfully,

"SENIOR FOREMAN."

(A foreman of fifteen years' experience.)

WOMEN IN THE DRAWING OFFICE.

To the Editor of Engineering.

SIR,—I am glad this correspondence has come to the notice of Miss Parsons because she, and not Mr. Morgan, should be the protagonist in the matter which naturally emerges from what has so far been said. From her letter I gather Miss Parsons is prepared to discuss the question of women draughtsmen in relation to their effect upon the engineering industry. And that is well, because no thinking person would contend in these enlightened days that employment was desirable for its own sake, and not merely as a means to an end.

Two reasons justify employment—the first, the efficient production of something necessary or desirable, which is the accepted reason at the moment. The second includes the first as a subsidiary reason, but primarily concerns itself with the effect of an occupation upon the worker's character, welfare, and happiness. That is an ethical, as opposed to a materialistic conception of work, and may be, some day, the governing factor. Let us be contemporary and materialistic, and guided by the first.

Miss Parsons has fallen into the usual error in supposing that theoretical knowledge, or the ability to calculate, can make a draughtsman. It can make a person useful for certain engineering processes, but I am merely concerned with what constitutes a draughtsman. Probably no one ever spent ten years in a drawing office without coming into contact with several cases of men who had very high mathematical and theoretical qualifications, but whose abilities as practical designing draughtsmen were feeble in the extreme. A typical case I was once familiar with was that of a man 26 years of age who was a B.Sc., and expected shortly to be a D.Sc.* His efforts in design after a year on the board were sometimes ludicrous, and he finally took his credentials to where they had greater weight, and taught students in an engineering college the theory of mechanical engineering. I quote the case to illustrate the broad fact that, although mathematics and theory are desirable, nevertheless the value of the practical draughtsman rests more upon experience than either.

Knowing this, draughtsmen have made the qualifications for membership of their association to depend, for the present at any rate, upon experience, and for Miss Parsons' information I will (with your kind permission) quote that part of our rules governing membership.

"*Rule* 3. (*a*) Members shall be of two classes—members and associate members.

"(*e*) A member . . . must be employed as a draughtsman, designer, calculator, or estimator at the time of application for membership, and shall have had at least eight years' engineering or shipbuilding experience, three years of which he must have spent as a draughtsman. The other five years may have been devoted to—

Technical education (full time).
Works experience.
Drawing office experience.
Designing, calculating or estimating.

"(*f*) An associate member . . . must be at least 18 years of age, and be employed as a draughtsman, designer, calculator or estimator at the time of application. He shall have had at least three years' engineering or shipbuilding experience, one year of which must have been spent as a draughtsman. The other two years may have been devoted as required for a member."

This, then, partly answers Miss Parsons' query as to whether we will admit women to membership. Directly application forms reach us satisfying the requirements we have imposed as necessary for a draughtsman, the inclusion of women in the association will become a practical question—and not before. Permit me another word. A draughtsman builds up his experience from year to year, and until the time arrives when his mental energies decline his value increases. When that time arrives he is generally thrown remorselessly on the scrap heap—without superannuation. For the reason that it is a loss to the efficiency of the industry to throw away experience by a premature discontinuance of the work, it seems desirable that women should sign an agreement to celibacy before admission as "junior draughtsmen." They will probably demur to this, and if, Sir, they have made up their mind to come into drawing offices, I, for one, shall not attempt the impossible by trying to keep them out. The cleverness and pugnacity they have displayed of late years in obtaining what they want would effectually prevent me from entering into a hopeless contest. Directly they have expressed their unalterable determination to become draughtsmen I shall not oppose them—I shall give a sigh of resignation, and retire into the back kitchen to wash up. But I hope they will (or, rather, wish they may) give some attention to the foregoing considerations before deciding.

I am, Sir, yours faithfully,

ERNEST H. WALKER
(Chairman, National Executive, A.E. and S.D.).

61, Claverton-street, S.W. 1,
November 24, 1918.

STUDENTS FOR DEGREE COURSES.

To the Editor of Engineering.

SIR,—Casually looking through your coloured cover sheets to-day I saw some gladdening news—that the University of Bristol proposes at present to accept students for degree courses without matriculation, on their showing evidence of good general education. I wonder to how many gallant lads, who have fought for us so well during the last five years, this decision will mean professional salvation. I could name a score among my own small circle of young friends whose ambition was to get their B.Sc. degree, but who might now find it impossible unless other universities adopt the same enlightened course. For these lads are four or five years older, and in many cases must be prepared to earn their own living at once.

I am writing only on behalf of those who would aim at degrees in Natural Science. I am among those who have always thought the matriculation examination rather unfair for the reason that the candidate must pass in certain subjects, some of which, for example Latin, history and literature, are frequently distasteful to the scientific student, and are only possible for him by undesirable cramming.

May I submit as a further temporary measure that selected students should, for the next two or three years, be allowed to take their degree course on evening class study only, giving them the opportunity of development on the practical side, and possible of earning an income simultaneously. I am aware that this would be a trying process, but many are equal to it.

I am, Sir, yours obediently,

T. ROLAND WOLLASTON, M.I.Mech.E.
(Chairman North-Western Section, Junior Institution of Engineers).

Lord's Chambers, 26, Corporation-street, Manchester,
November 25, 1918.

MINING ENTERPRISE IN GALICIA.—Under the style of Rudy Zelame, a limited company has been formed under the auspices of two Galician banks and the Tepege mining concern, for the purpose of exploiting iron ore deposits in Galicia and Poland, and establishing iron works Operations have already commenced.

THE RICHARDS THREAD MILLING MACHINE.

(*For Description, see opposite Page.*)

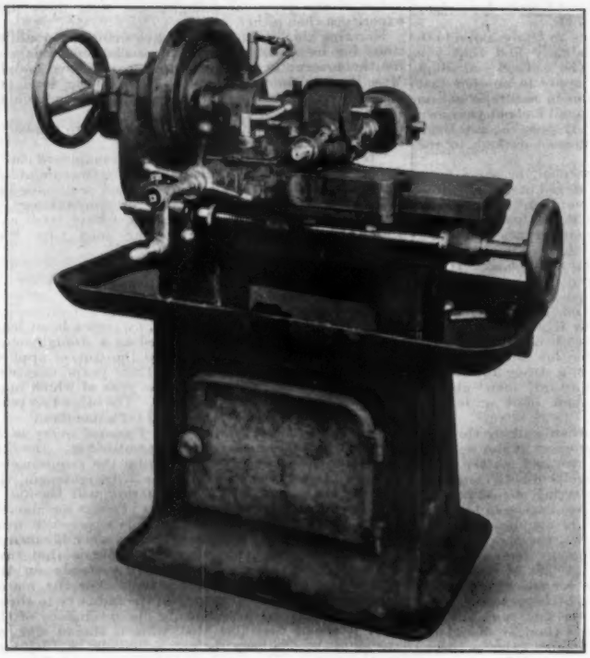
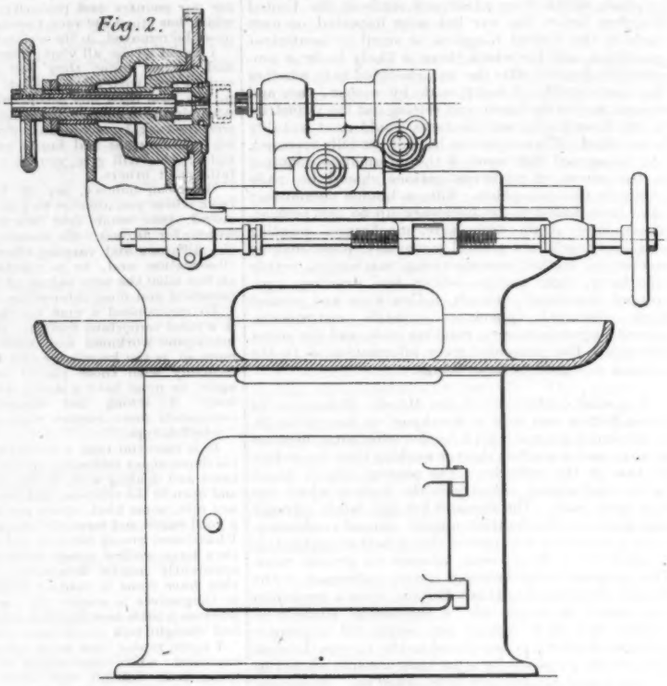
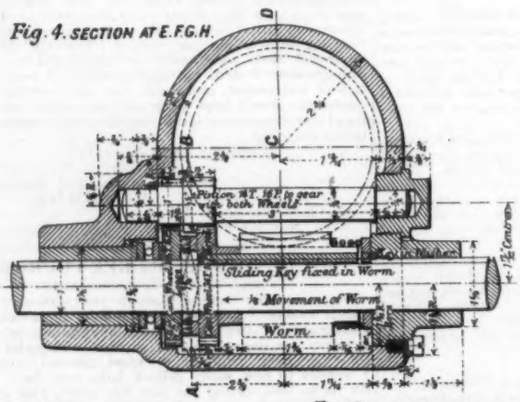


FIG. 1.

Fig. 2.





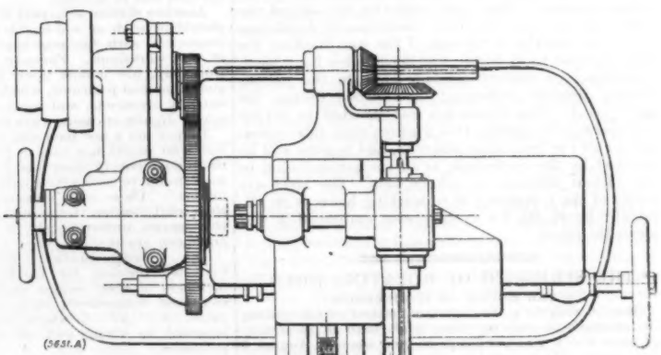
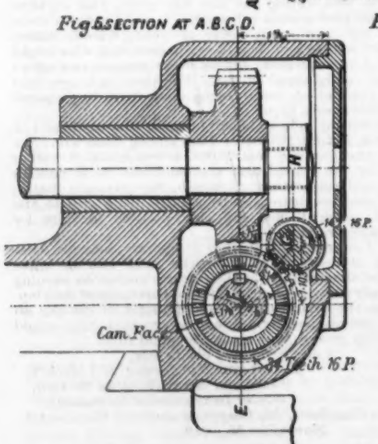
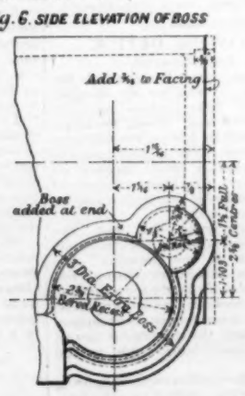


Fig. 3.





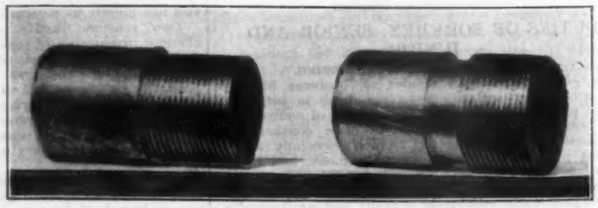


FIG. 8.

THE RICHARDS' THREAD MILLING MACHINE.

No branch of machine work has received a greater impulse during the war than thread milling. The obvious reason is that female and other unskilled labour can be taught to cut threads on a milling machine far more quickly than on a screw-cutting lathe, and once the machine is set it is almost impossible for mistakes to be made or bad work turned out. There are several types of thread millers on the market doing excellent work, and the most recent is that brought out by the Richards' Thread Milling Machine Company (1918), Limited, of 14, Outer Temple, 222, Strand, London, W.C. 2, which we illustrate on the opposite page. The outstanding feature of this machine is that there is only one adjustment to make, that is the depth of the cut. Once this is fixed—a very simple matter—the cutter does all the rest. It has not to be adjusted to the angle of the thread, or to the pitch, or to the lengths of the screw. All these points are provided for in the hob, and the most careless operator cannot make a mistake or upset the adjustment.

Fig. 1 is a general view of a machine of small size, Fig. 2 an elevation, Fig. 3 a plan and Figs. 4 and 5 details of the cam gear. It will be seen (Fig. 2) that the headstock carries a chuck in which the blank is held, and has a hollow spindle for accommodating long stock to be cut off in pieces as the work proceeds. Upon the headstock is a spur wheel gearing with a pinion on the side shaft which carries the cone pulley. The milling cutter is also driven from the same shaft through a pair of bevel wheels and a worm and worm wheel (Figs. 3, 4 and 5), the arrangement being such that the chuck and the milling cutter make the same number of revolutions. Fig. 1 shows the machine fitted with a cutter for male threads, while Figs. 2 and 3 show it with a cutter for female threads.

The milling cutter is made, in the first instance, as a screw of the same pitch as the thread which it is intended to cut, and of somewhat greater length. It is then grooved, parallel to its axis with numerous grooves, and after that the teeth which are thus formed, are backed off. It will be understood that the cutter presents a large number of teeth, arranged around the axis in spirals which are of the same pitch as the screws to be cut, but of larger diameter for external cutting, and smaller diameter for internal cutting. If now a blank be put in the chuck and the cutter fed up to it by the hand wheel shown (Fig. 1) each tooth of the cutter will remove a piece of metal as it comes round, and as the cutter and the blank revolve at equal speeds the cut will go deeper and deeper as the cutter is fed forwards. To produce a perfect screw in this way there should be an infinite number of teeth, because any less number would produce a polygon instead of a circle. There is clearly a limit to the number of teeth on such a cutter, but by means of the ingenious arrangements shown in Figs. 4 and 5 it has been found possible to produce the same effect as would be given by a cutter with an infinite number of teeth.

It was stated above that the chuck and the cutter revolve at equal speeds. This statement, however, is not quite correct. The average angular speeds are the same, but the cutter is subject to successive slight accelerations and decelerations, with the effect that any given tooth on the cutter does not fall twice on a particular spot on the blank. When the cutter is being accelerated the tooth comes round rather earlier and meets the blank sooner than it did at the previous revolution, and contrarywise, when it is being decelerated it comes round later. In effect this is equivalent to dividing up the cutter into a number of teeth equal to the actual tooth spacing multiplied by the number of teeth in the smaller of the two gear rings.

The mechanism for alternately quickening and retarding the revolution of the cutter is shown in detail in Figs. 4 and 5. The worm wheel, as already explained, is driven by a worm on a cross-shaft. This worm can slide endwise on its key, and is continually forced to the left (Fig. 4) by a spring. At the end it carries a ring with a cam face which is shown developed in Fig. 7. This face is in contact with a similar face on a ring loose on the shaft. Both rings have teeth around their peripheries—one has 34 teeth and the other 35—and these gear with a pinion of 14 teeth just above them. Clearly the two cam faces revolve at different speeds, with the result that the worm is pushed backwards and forwards along its shaft, and thus first increases and then decreases the angular speed of the wormwheel, and thus alters the relation of each tooth on the cutter to the blank as already explained.

Figs. 8 and 9 show two specimens of work. In one the cutter has left a clean square shoulder into which the thread dies, and the other has worked up to a groove previously cut. This groove might have been made simultaneously if a plain milling cutter had been attached to the threaded cutter.

THE TATA HYDRO-ELECTRIC POWER-SUPPLY WORKS, BOMBAY.*

By Robert Batson Joyner, C.I.E., M.Inst.C.E.

This paper describes large works for supplying Bombay with water power for its numerous mills and factories, which have hitherto used steam power, to the extent of over 100,000 h.p. Coal in most of India is too expensive to allow competition with other countries for many products, though the raw materials are grown, or are found, in India, and labour is cheap and docile, while highly educated Indians abound.

The water power now provided is very much cheaper than power from coal or oil, gives a better "drive," and frees Bombay from the clouds of deleterious smoke which the poor Indian coal gives.

The works described take advantage of the remarkable circumstances of the very heavy rainfall on the precipitous edge of the Western Ghats, about 2,000 ft. above, and about 40 miles from, Bombay. As the rain falls only during three or four months of the year, and the watercourses are dry all the rest of the year, it was necessary to store water sufficient to give about 100,000 h.p. for 10 hours or 12 hours a day during about nine months of the year.

Three lakes are formed by four masonry dams, ranging from nearly ¾ mile long and 34½ ft. high to nearly 1¼ miles long and 96 ft. high. Two of these form a "Monsoon" lake of sufficient capacity to provide power during the longest "breaks" in the monsoon, and thus give an uninterrupted supply of power for three months and more. The other lakes are for storage, and maintain the power during the eight or nine months in the year when no rain falls.

The monsoon rain on the Western Ghats, though always heavy, is very variable in amount. The least annual amount during the last forty-eight years was 82 in. on the edge of the Deccan plain, and the greatest amount during the past eleven years, in which special gauges have been fixed, on hill-tops as well as in plains, is 546 in., which fell in a little over three months, 460 in. falling in about two months. The minimum fall of 82 in. is very exceptional, and the maximum given may be equally so. The combined available capacities of the two storage lakes is about 10,100,000,000 cub. ft., whilst the water required to give 100,000 h.p. ex turbines for nine months, allowing for the great loss by evaporation and by soakage, and for friction in the pipes and turbines, is 6,700,000,000 cub. ft. The excess capacity is given owing to the very variable amounts of the monsoon rains, so as to carry on the balances in years of excessive rainfall to make up for the occasional short monsoons. It was arrived at by assuming the works had been completed forty years ago, there being one rain-gauge record covering that period—which includes four minimum years' fall—and deducting from each year's supply the amount which would have been used, lost by evaporation, run to waste, or carried on to the next year, which gives the excess capacity required for a sufficient number of years.

The amount of 546 in. measured at one hill station in the lakes catchment is not more than has been measured in two or three years out of the past fifty odd years at Cherrapunji, in the Assam Hills, which has the heaviest rainfall hitherto known, but there rain falls during seven months of the year, so that the amount measured for this work, for that particular year, may claim to be the heaviest rainfall ever yet measured.

The works are notable for the following reasons. They are the largest of the many similar hydro-electric works which have been constructed during the past ten or twenty years, taking into consideration the great head used, combined with the large discharge of water. The first is equal to about five times the height of St. Paul's Cross, and the latter is greater than the summer flow of the River Thames during five months. They are also the first works to store water for power for use during about three-fourths of the year. One of the masonry dams, taking the exposed face area, is probably the largest yet constructed. The works are probably unique, considering the very heavy rainfall and the very steep rocky slopes, giving the greatest discharge perhaps ever recorded. The catchment area of the two lakes is only 16½ sq. miles, while of this the full lakes area is about 7½ sq. miles.

The water is led from the monsoon lake and from the two storage lakes, which are joined together by a tunnel a mile long, by two ducts, together 4·63 miles long, to the forebay at the top of the great precipitous scarp which forms the western boundary of the Deccan plateau. From there the two lines of steel pipes are taken down the steep slopes and precipices to the power-house, about 1,750 ft. below the forebay, the length of single line being about 2·33 miles. The pipes at the top are 82½ in. in internal diameter, and at about two-thirds of the total height down, the diameter is 72 in. Here they are joined by a double swan-neck pipe from which eight smaller pipes are led down to the power-house, their diameter being 3¼ ft. at the top, and 3 ft. 2 in. at the bottom. The thickness of the metal at the top of the large pipes is ¾ in., and at the bottom of the small pipes 1¼ in.

The difficult work of laying and fixing these pipes some of which weighed 7 tons, down the precipices, is described in detail.

Each of the lower smaller eight pipes supplies a Pelton-wheel turbine, designed to give a maximum of 13,500 h.p. with automatic regulation devices, which are described.

*Abstract of a paper read before the Institution of Civil Engineers on Tuesday, November 19. An illustrated account of the Tata Power Supply Works will be found in Engineering of October 24 & 31, 1913.

The question of the desirability of using Portland cement for masonry dams is raised. It is never done in India. To build dams there with Portland cement would render such works financially impossible, and hydraulic lime mortar is also considered to be better adapted for the purpose.

The paper describes the main causes of the Indian monsoons and how they are affected and diverted by local circumstances; how the abrupt precipice of the line of Western Ghats causes the rapid condensation of the warm moist air from the sea, drawn in by the upward dry currents of light air over the plains of India and Central Asia. The effect is shown of the wide blacksoil plains of the Deccan, bare of crops during the south-west monsoon, in preventing condensation of the air already deprived of so much of its moisture by the Ghat lines thus tending to cause draughts and famine; and means are suggested for minimising such conditions.

The paper also shows the effects of forests and vegetation and bare hill sides in altering the conditions of rainfall, the great variation in the amounts of evaporation according to different local circumstances, and the great importance of all these facts in the consideration of power from lofty heads of water. In the works described 1 cub. ft. per second will give 154 h.p. ex turbines, which could be given for a year with about ⅝ in. depth on the storage lakes.

The works described are the first to be undertaken of a number of similar works proposed by the author, he having shown that it is financially possible in India to store water for use during eight or nine months of the year, and give power at a much cheaper cost than by the use of coal, oil, or spirit from vegetable products; likewise cheaper than power from the wind, sun, or tides. And not only that, but the water after use is available for irrigation, so valuable in a country without a drop of rain for a large part of the year. This would ensure the growth of the raw materials required for finished products on which the country is now so dependent upon other countries. It would also supply the factory workers or others with food and drink, and help to prevent famines, besides doing much to regularise the rainfall. Such power will provide electric traction for raw materials to, and finished products from, the factories, as well as light for them and neighbouring towns, produce fertilisers, and give the great heat required for the smelting of ores. Many industries would then be self-contained and India could compete with Europe, America or Japan for its finished products, and would become less dependent upon its agriculture, which the varying seasons render somewhat capricious.

The fairly approximate coincidence of the sun-spots minimum with years of bad Indian monsoons during the past fifty years is shown by diagram.

Novel Dry-Dock Construction in Sweden.—The large Swedish concern Ljusne-Voxna, which is going to acquire its own tonnage, is constructing a dry docks, both for its own and other vessels on a novel principle. The dock, which is to be located at Ljusne, North Sweden, will be 100 m. (328 ft.) in length and of considerable breadth; it will be able to accommodate vessels of 4,000 tons deadweight. The dock has been designed by chief engineer M. Von Eckermann and will be built on land above water-level. The vessels from the harbour will enter a lock and will then be raised and lifted into the dock by means of water from the water-power canal of the Ljusne face. By this arrangement the dock can be filled and emptied without any pumping plant, and in consequence the cost of docking will be low.

Standardisation of Railway Equipment.—The Advisory Council under the Ministry of Reconstruction have now issued their report upon the Standardisation of Railway Equipment. They think it desirable in the national interest to carry out this standardisation as far as it is practicable to do so, and as immediate steps towards this end they recommend: (1) That the standardisation of wheels, axles, wheel centres, tyres, running gear, draw gear, buffing gear, bogies, brakes and under frames be dealt with immediately by the Engineering Standards Committee on which all interested including private builders and makers of materials, should be represented, and that when such essential parts have been standardised, the adoption of the standards should be gradually enforced. In view of the difficulties of standardising complete locomotives and other rolling-stock under existing circumstances and of the excessive amount of deadweight now carried on British railways, they recommend: (2) That a committee be formed to investigate the existing conditions of structural gauges and clearances of the British railways and the loading and unloading arrangements at works and ports in order to ascertain how far uniformity could be introduced and tares reduced, and at what cost. (3) That the costs of construction of locomotives and rolling-stock by the railway workshops and by private firms respectively be investigated and ascertained by competent independent accountants appointed by the Government. In view of the great demand for rolling-stock that there will be at the close of the war in this country and elsewhere, they feel that, in order to expedite delivery and to secure production at the lowest possible cost, standardisation is very necessary for the export trade. They recommend, therefore: (4) That the consulting engineers and representatives of railways financed by British capital in foreign ports and in the Dominions be brought together to confer with the locomotive and wagon manufacturers in this country to determine what standardisation can be effected, and that, with a view to the possibility of effecting partial international standardisation, the separate committees should take cognisance of each others investigations.

SOCIETY OF GLASS TECHNOLOGY.

The November meeting of the society was held in the Queen's Hotel, Leeds, on the 20th inst., Mr. F. W. Branson, F.I.C., occupied the chair. Previous to the meeting members paid a visit to the works of Messrs. Lax and Shaw, Albert Glass Works, Hunslet. A unanimous vote of thanks to Messrs. Lax and Shaw was passed by the meeting, their courtesy and kindness being much appreciated.

The first paper entitled "*Silica Refractories for Glass Works Use*," was read by Mr. W. J. Rees, F.I.C. The author first outlined the various uses to which silica refractories could be put in glass works, and briefly dealt with the provisional specification that is being set up by the Glass Refractories Committee. He next dealt with the raw materials required in the manufacture of silica bricks, &c., and the methods employed in this manufacture. He showed that the presence of iron in the form of magnetic oxide of iron was not detrimental to the properties of a silica brick. The lowest silica limit was put at 94 per cent., and it was shown that the presence of much alumina or more than 2 per cent. of lime was not advisable. Lime is certain to be a constituent of the silica brick as lime slurry is used as a "bind." It is of interest to note that in some cases lime has a bleaching action, and masks any colour likely to be set up by the presence of iron compounds. Some users of silica bricks insist on a white or light-coloured brick and reject dark-coloured reddish bricks. It has been proved that the colour of a brick is not the least criterion of its refractoriness.

Silica bricks may be either coarse or fine in texture, but the texture must be uniform throughout. Coarse-textured bricks are better for withstanding sudden temperature changes, but they are worse from the point of view of attack by chemical fumes. Great advantage is gained in the manufacture of bricks if 25 per cent. of the materials is in the form of impalpable silica powder and the remainder in the form of grains with a maximum diameter of ¼ in.

The various modifications of silica were discussed, and the volume changes taking place with rise of temperature received full treatment. In conclusion, the author discussed silica cements which should contain at least 92 per cent. silica, and should only be used as a wash. A discussion followed in which Professor W. G. Fearnsides, Mr. C. J. Peddle, Mr. Gardiner, Mr. J. G. Clarke and Dr. Turner took part.

The second paper, on "*The Properties of Soda Lime Glasses* (1) *The Annealing Temperatures*," by J. H. Davidson, M.Sc., F.I.C., S.English, M.Sc., A.I.C., and W. E. S. Turner, M.Sc., D.Sc., was read by Dr. Turner. A series of 14 allied glasses had been made, beginning with a simple soda-silicate, and the effect of adding increasing amounts of lime, on several of the properties of glass had been studied. The batches used were communicated, and the results obtained for the annealing temperatures. It was shown that the annealing temperatures increased with an increasing amount of lime. Increasing the lime percentage also improved the durability, and caused the glass to "set" quicker. A batch for a bottle glass was given, which showed little or no tendency to "crizzle," thus being different from the majority of soda-lime silicate glasses. Mr. Rees, Mr. C. J. Peddle and the author joined in the discussion that followed.

The following papers were not read, but will be printed in the Journal in due course: "The Determination of Boric Oxide in Glass," by J. D. Cauwood, M.Sc., A.I.C., and T. E. Wilson, B.Sc.; "Note on the Use of Arsenious Sulphide as a Flux in Glass-making," by J. H. Davidson, M.Sc., F.I.C. The next meeting of the society will be held at Sheffield in the university, on December 18, 1918.

THE ROYAL AIR FORCE.

For the first time during the war, it is possible to disclose official details of the remarkable fighting aircraft which enabled the Royal Air Force to play so notable and conclusive a part in the aerial defeat of Germany and her Allies. It is well known that during the final stages of the war Great Britain has been turning out large numbers of the fastest and most powerfully-armed aircraft in the world. Indeed, the collapse of Germany in the air, which was so noticeable a feature of the last phase of the operations, was largely due to the fact that, not only was she confronted with an air force immensely superior to her own in all those personal qualities which constitute fighting morale, but that she was at last definitely outclassed in the speed, climb and fighting efficiency of the super-aircraft which British inventive genius brought into the field. Roughly, the machines employed by the Royal Air Force upon the fighting fronts may be divided into three groups:—(1) *Reconnaissance Machines*: Used for contact patrol work over the lines, the direction of artillery fire, photography, and general strategical reconnaissance. (2) *Heavy Bombers*: Capable of travelling long distances without escort, and carrying heavy loads of bombs in addition to defensive armaments. (3) *Fast Fighting Scouts*: Possessing exceptional climbing powers, heavily armed, and capable of manœuvring at a very high rate of speed.

The earliest type of British reconnaissance machine was the now famous B.E.2 C., designed and produced by the Royal Aircraft Factory at Farnborough. The design was completed just prior to the outbreak of war, a fact which facilitated immediate production for the use of the Expeditionary Force. As far as possible, speed, climb and manœuvring ability were combined, although compared with modern types it was a relatively slow machine, making only 50 miles to 60 miles an hour with the 80-h.p. engine with which it was originally fitted. This was followed by the Armstrong-Whitworth F.K. 8, fitted with 160-h.p. Beardmore engines, which made an average speed of 82 miles an hour and could climb to 10,000 ft. in about 27 minutes. Towards the end of 1916, an immense forward stride was taken by the production at the Royal Aircraft Factory of the R.E. 8 with a 12-cylinder R.A.F. engine. This machine has done the bulk of the artillery observation work in France, directing all big-gun fire and barrage work. At 10,000 ft. it has a speed of 92 miles an hour, and can climb to that height in 11 minutes. It is fitted with camera and wireless equipment, and takes photographs of every "shoot." An even bigger advance was marked by the introduction of the "Bristol Fighter," a long-distance fighting reconnaissance machine, capable of travelling at 113 miles an hour at 10,000 ft., and climbing to that height in 11 minutes. Had the war continued, the Bristol Fighter would have entirely replaced the R.E. 8 for long-distance artillery work.

Aerial bombing was first undertaken in France by the Avro, a machine of moderate speed fitted with an 80-h.p. Gnome engine. The observer's seat was used as a receptacle for the bombs, which were merely thrown overboard without the aid of the scientific bombing sights and elaborate bomb-dropping gear which have since contributed so largely to the wonderfully accurate shooting made during the raids upon Germany. The first British machine specifically constructed for bombing purposes was the Short, a modified sea-plane, fitted with a 250-h.p. engine, and carrying four 112-lb. bombs under each wing. This type, which did most useful work in France, was followed by the Sopwith 1½ Strutter, and later by the highly-improved D.H. 4 and D.H. 9 machines. The D.H. 4 machine was originally designed as a fighter, but its trials disclosed such excellent lifting powers that it was converted to bombing purposes. It is capable of climbing to 10,000 ft. in 9 minutes, and has an endurance of 3¾ hours. The D.H. 4 and D.H. 8 machines have been fitted with Rolls-Royce, B.H.P., and latterly the Liberty engines.

Finally, the great Handley-Page machines were devised for the bombing of Germany. The first quantity production was begun in August, 1917, and the performance of the machine has justified the highest expectations. It is capable of carrying 2,000 lb. weight of bombs in the fuselage, or 1,500 lb. to suspend externally. The machines used by the R.A.F. Independent Force in the bombing of Germany have been the Handley-Page, D.H. 4, D.H. 9, and Sopwith "Camel." Not until the middle of 1915 were production machines armed with standard equipment. Two of the earliest types were the F.E. 2 B. and the Vickers' "Fighter." Both had an open cockpit, and were equipped with Lewis or Vickers' machine guns. The year 1916 witnessed the introduction of the fixed machine gun firing through the propeller and fitted with the ingenious Constantinesco interrupter gear. Other types followed, rapidly leading up to the S.E. 5A, and lastly the Sopwith "Dolphin," the best and latest British fighting scout in the field. Both these types were in use at the termination of hostilities. Some idea of the power of these modern aircraft can be gained from the fact that the Dolphin travels at 128 miles an hour at 10,000 ft., and climbs to that height in 8¼ minutes. It lands at upwards of 55 miles an hour. The following table shows the performance of the leading British types. (At lower altitudes the machines will, of course, develop higher speeds):—

Machine.	Speed at 10,000 Ft.	Time Required to Climb 10,000 Ft.	Continuous Flight Capacity.
		minutes.	hours.
F.E. 2 B.	76	40	3½
Vickers' Fighter	76	40	3½
Sopwith 1½ Strutter.. ..	103	10	—
Bristol Scout..	111	10	1½
A.W.	88	27	3
Sopwith Camel	118	10	2½
D.H. 4	120	11	4
D.H. 9 A.	120	11	6
Bristol Fighter	113	11	3
S.E. 5 A	126	10	3
Dolphin	128	8¼	1½

It is impossible to convey an adequate idea of the immense mechanical difficulties which have had to be overcome in the evolution of these types, with their countless accessories, under pressure of an unprecedented man-power crisis, when demands of inconceivable magnitude and urgency were being made upon every possible source of British industrial activity. The call for new and increasingly powerful machines (in ever-increasing numbers) came just at the time when Britain's manufacturing capacity was being taxed to the uttermost to increase the shipbuilding output, to supply the urgent needs of the British Admiralty, and to produce the immense quantities of guns, shells and other munitions required by our rapidly-growing armies at the front, and by many of our Allies.

Calcium Carbide.—On and after December 1, 1918, all restrictions as to the sale or purchase of calcium carbide will be removed, subject to a maximum price to consumers of 40*l.* per ton for quantities of 1 cwt. and over (granulated, 10*s.* per ton extra). No application for the use of this material or returns of stock, need be made to the Ministry of Munitions after the above-mentioned date. It is anticipated that supplies are available for all purposes and will be distributed through the ordinary trade channels, but should the exigencies of the ship-building trade demand it, the Government reserves the right to give preferential deliveries.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Immediately hostilities ceased measures were taken to reduce output, and at the same time carry on as far as possible pending the change-over to peace industries. All overtime and working over the week-end was dropped. Thousands of shell girls have been instructed to hand in their notices; a fair number of other workers have been dismissed or have gone on short time. The National Shell Factory at Templeboro', on the edge of the city, had 5,000 women and 1,000 men employed. These have been dropped in batches. It is estimated that from 30,000 to 40,000 who had never been in the workshops before the war were employed on war production in Sheffield alone. These are being rapidly demobilised. An effort, however, has been made to maintain a normal going-on for pre-war workers. Now that war control is relaxed it is permissible to pay a tribute to the magnificent way in which certain branches of Sheffield trade were organised. This was only made possible by the enterprise of the city's modern university, or, more strictly, through the activities of their Department of Applied Science. This department was the means of organising all the smaller engineering and electro-plate trades; providing them with tools and skilled supervision. Their record was a remarkable one. Millions of shells, Stoke's bombs, brass stampings, trench howitzers, &c. were produced by firms newly harnessed to war work. The Non-Ferrous Metal Department solved the problem of manufacturing cupro-nickel, the alloy which has superseded "German silver" in all the numerous branches in which that metal is employed. The Engineering Department were responsible for some 2,000 gauges for the exact working of shells and material. In the manner in which it threw its whole energies into the breach at a time of pressing need, Sheffield University deserves well of the nation. An outstanding feature of Sheffield trades this week is the uncertainty of the markets. Holders of stock are anxious to unload, but buyers, fearful of the present high rates, are only purchasing from hand to mouth. Manufacturers welcome the announcement that supplies of steel are available for ordinary industries. The scope for trade development is immense. Huge extensions of works have taken place, but already manufacturers are almost overwhelmed with inquiries from all quarters which had to be disregarded during the war. The long-neglected tram tracks are a fertile source of business. The makers of railway rolling-stock have a busy time in front of them. Mining machinery, crushers, and the like, are wanted in immense quantity. Sheffield's capacity for steel production has been enormously increased, over 100 new furnaces having been laid down during the war period. There is a great future for the city when the change-over is complete, which in many cases, however, will not be for months to come.

South Yorkshire Coal Trade.—The position of the house coal trade from the supply point of view continues most unsatisfactory. Merchants are quite unable to cope with orders, and as the pits are still working on reduced staffs owing to the influenza epidemic there is no hope of any immediate recovery. Steam coal is moving freely, and values are unaltered. There is, however, less pressure and a more optimistic feeling prevails. Several furnaces have been set down for repairs, with a consequent lighter demand for coke. Any substantial reduction in the production of coke means the release of a big bulk of slacks and nuts, which in turn should improve the supplies for gas and general manufacturing purposes. There continues a big demand on Admiralty account, and there is no reduction in the tonnage required for export to allied countries. Stocks are at low levels. Current quotations at the pits are as follow:—Best branch handpicked qualities 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

The London Iron and Steel Exchange.—The formation of the London Iron and Steel Exchange, Limited, which was made public last week, is attracting a great interest, and many inquiries are being received. We learn from the secretary that the rules and regulations are now in the press, and will shortly be issued, giving all particulars. We hope shortly to be able to publish the official announcement of the opening.

A New Theory of the Steam Turbine.—The series of articles on the above subject by Mr. H. M. Martin, which appeared in our columns during the past summer have been reprinted in pamphlet form, together with the steam chart based on Callendar's formulas and tables. Copies, price 2*s.* 6*d.*, can be obtained at the offices of Engineering, 35 and 36, Bedford-street, Strand.

Death of Mr. H. Cecil Walker.—We regret to have to announce the death, in his forty-second year, after a short illness, of Mr. H. Cecil Walker, the eldest son of Mr. Henry C. Walker, chairman of Waygood-Otis, Limited, Falmouth-road, London. Mr. Walker entered the shops of R. Waygood and Co. in September, 1893, and in time occupied the position of chief electrical engineer to the company. In November, 1910, he was appointed to a seat on the board of directors, and this he retained after the amalgamation with the Otis Elevator Company, Limited.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The altered conditions in connection with the manufacture of steel are very real and give rise to much speculation as to how the steel-making industry will ultimately be affected Difficult problems regarding many important points will require to be solved, and although at the moment the outlook is rather unsettled still the mills are running at full pressure, work is plentiful and the activity as ceaseless as when weapons of war were being forged day and night. It will be a long time before the ravages of war can be repaired, but the task of doing so will be so extensive that steel-makers have vast opportunities in front of them. Meantime it is well, perhaps, that Government control of prices should continue, at least during the most difficult period of transition from conditions of war to those of peace, this being the only way by which actual values will be again arrived at. Without question present rates are artificial, yet untold complications would undoubtedly arise were control suddenly withdrawn—things must be in a more assured position before this takes place. Steel is in great demand at the shipyards, for although Admiralty work will fall out for a time the construction of mercantile shipping will make for much business.

Malleable Iron Trade.—Judging by all accounts there is little fear of inactivity in the malleable iron trade, at least for some considerable time to come, as orders are simply flowing in, a condition of things with which makers are not likely to grumble. Every mill is running to its fullest capacity, and the various alterations and extensions which have recently been inaugurated must be of great service now. Agricultural parts, &c., are being much run upon, and so also are small sizes, and bars for bolt and rivet work. The malleable iron trade, therefore, seems likely to share very materially in the era of prosperity which industry will enjoy in the near future.

Scotch Pig-Iron.—With the removal of the feverish demand for pig-iron, red hot from the furnace, smelters once more find themselves able to accumulate stocks, the first process in the establishment of normal conditions. The ordinary mercantile consumer will get some of his own back now, especially as increased supplies of raw ore are already coming to hand. With the expansion of both home and export trade, a brisk volume of business may be looked for.

Shipyard Transfer at Port Glasgow.—Messrs. William Hamilton and Co., Limited, Port Glasgow, have just sold their premises known as the "Glen Yard" to Messrs. Russell and Co., shipbuilders, Port Glasgow, a neighbouring firm. By this extension, which is to come into force early next year, Messrs. Russell will be enabled to have berthage accommodation for eight additional vessels of large tonnage, with launching ways right out to the open Firth. By this transfer Messrs. Russell and Co. will become possessed of four of the largest shipbuilding yards in Port Glasgow, this giving them an aggregate constructive capacity of over 30 large vessels, a fact which augurs well for the future prosperity of what is now one of the busiest towns on the lower reaches of the Clyde.

Launches on the Clyde.—The first concrete ship built in Scotland has just been launched at Greenock by the Scottish Concrete Ship Company, Limited. Built to the order of the Controller-General for Merchant Shipping, the new vessel is a barge, 180 ft. long, with a carrying capacity of 1,000 tons deadweight. The building of standard ships goes on apace, and in launching their seventh vessel of this type from their Govan yard, Messrs. Harland and Wolff have demonstrated very clearly what can be accomplished when exceptional circumstances arise. This new vessel—the War Cowslip—belongs to the "A" type, is of 8,200 tons deadweight, and 400 ft. in length by 52 ft. beam, while the machinery installation has been supplied by the Diesel Engine Works, Glasgow, now a very important branch of the firm's activities.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is at present a good deal more Cleveland pig-iron available for disposal than can be dealt with, the chief obstacle being the serious shortage of trucks. Hope is entertained of better supply in the near future. Meanwhile distribution is carried on as expeditiously as conditions permit. Transactions with the Allies are proceeding steadily and there is large demand on behalf of neutrals, but trade with the latter is still practically nil, home and allied needs still taking up what iron can be disposed of. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge are all quoted at 95*s.*, and No. 1 is 99*s.*; whilst for shipment to France and Italy, No. 3 and the lower qualities are 122*s.* 9*d.* and No. 1 is 127*s.* 9*d.*

Allocation of Cleveland Pig-Iron Discontinued.—The Controller of Iron and Steel Production announces the discontinuance of the allocation system so far as it refers to Cleveland foundry pig-iron. Whilst, of course, this does not mean that unlimited supplies will be available, consumers may now place their orders as they please. To ensure fulfilment of what the Government consider urgent work, however, priority certificates will still be issued.

Conveyance of Iron to Scotland.—Another important announcement by the Controller is the discontinuance of arrangements through the official channel of conveyance of pig-iron from Middlesbrough to Scotland by steamer. The intimation is to the effect that the arrangements by which the Ministry were liable for excess freight over and above the railway rate, from makers to consumers' works cease, and it is considered that under the conditions which now exist, any further shipments that may be made should be subject to arrangement by the consumers themselves, and that the Ministry is not called upon to continue the previous arrangement.

Hematite Iron.—Control of distribution of East-Coast hematite is apparently still necessary, and likely to continue so until output is increased, though it is gratifying to have the assurance that production is just about equal to demand. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Foreign Ore.—With freights and insurances falling, business in foreign ore is expanding. Imports are coming forward on quite a good scale, and most consumers have very considerable stocks to draw upon.

Manufactured Iron and Steel.—Output of local steel works has been seriously reduced by the armistice holidays followed by a week's strike. There is heavy pressure for delivery of articles needed for the shipyards, and other heavy material is also in keen demand, but some of the smaller works are feeling the effect of the cessation of war contracts. To home customers the following are among the principal market quotations: Common iron bars, 14*l.* 15*s.*; best bars, 15*l.* 15*s.*; double best bars, 16*l.* 15*s.*; triple best bars, 17*l.* 15*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; iron ship rivets, 21*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel strip, 17*l.* 10*s.*; steel hoops, 18*l.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*—all f.o.t. at works. Advances in export prices are expected to be announced this week.

The Steel Strike.—The strike of sample passers and steel smelters, which had laid thousands of men idle on the North-East Coast, was of less than a week duration. On Friday last, following branch meetings held in the morning, the men's delegates met at Middlesbrough and reported the decisions of their members, which were in favour of an immediate resumption of work on the undertaking given by the employers that all the grievances will be dealt with within a reasonable period.

Coke.—Coke continues in very ample supply for use at local blast furnaces, but is scarce for other purposes. Average furnace kind is 33*s.* at the ovens, and quality low in phosphorus 35*s.* 6*d.* at the ovens.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—There is not much in the general situation this week except that the shortage of all classes of coal is becoming increasingly accentuated. Notwithstanding the efforts made by colliery companies, there is really no great improvement in output as compared with last week, and supplies are consequently very short of requirements. The collieries are now abundantly supplied with tonnage, and the dock authorities are shipping as fast as their existing facilities will allow. The cessation of hostilities seems to have the effect of increasing the demand on allied account, and although some quantities are released for private trading, there is practically no coal—beyond what is absolutely necessary—being released for neutrals. There are at present at the local docks many vessels waiting for shipment to neutral countries, and the period of detention is stated in one case to have already exceeded a month. Smalls, too, are finding prompt outlets, primarily for bunker and coking purposes. Pitwood and iron ore are plentiful at fixed prices.

Newport.—The pressure of the demand for Monmouthshire coals is fully maintained, and collieries are assured of full stems for some time to come. Steams are in chief demand, but there are pressing inquiries also for the more bituminous qualities, and smalls are almost as actively supported as large coals.

Dry Steam Coal Combine.—Mr. D. R. Llewellyn, who, by his colliery enterprises during the past few years, has leapt so prominently into the foreground of the South Wales coal trade, continues to extend his interests in the coalfield. It was announced yesterday that, subject to the necessary formal consents, Mr. Llewellyn has just purchased the Ynysfais properties of the Troedyrhiw Coal Company, in the upper reaches of the Rhondda Valley. These properties consist of three well-equipped pits developing a taking of 1,000 acres of the least dry steam coal and at present yielding an output of 300,000 tons per annum, while the unworked reserves are very extensive. There are only two important dry steam collieries outside the combine now practically controlled by Mr. Llewellyn. He is a director of several other colliery companies, but his control over steam coals is now estimated at about 4,000,000 tons per annum, which represents, roughly, 70 per cent. of the dry steam coal output of the South Wales coalfield. Associated with Mr. Llewellyn in the sale of these coals are Mr. H. Merrett and Mr. Roger W. Price.

TOTALLY-ENCLOSED DIRECT-CURRENT MOTORS.—The Enclosed Motor Company, Limited, Finsbury Court, E.C. 2, who introduced some time since an effective pattern of alternating-current enclosed motor, are now manufacturing also direct current totally enclosed motors. By a system of circulating through a radiator the air trapped inside the motor, the temperature of the latter is kept at least as low as is usual with unenclosed motors of equal size and output.

NOTICES OF MEETINGS.

THE SOCIETY OF ENGINEERS.—Monday, December 2, at 5.30 p.m., in the Apartments of the Geological Society, Burlington House, Piccadilly, W. A paper, entitled "Notes on Railway High-Capacity Wagons' Wheel Axles" (illustrated by lantern slides), will be read by Mr. H. Kelway-Bamber, M.V.O.

THE ROYAL SOCIETY OF ARTS.—Monday, December 2, at 5 p.m., Cantor Lecture: "Physical Chemistry and its Bearing on Chemical and Allied Industries," by Mr. James C. Philip, O.B.E., M.A., D.Sc., Professor of Physical Chemistry, Imperial College of Science and Technology (Lecture 1). Wednesday, December 4, at 4.30 p.m., Ordinary Meeting: "Housing after the War," by Mr. Benjamin Seebohm Rowntree. Lord Henry Cavendish Bentinck, M.P., will preside.

THE RÖNTGEN SOCIETY.—Tuesday, December 3, at 7.30 p.m., at King's College Hospital, Denmark-hill, S.E., when there will be a visit to the Radiographic and Electrotherapeutic Department. Demonstrations of the apparatus will be given.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 3, at 5.30 p.m. Paper to be further discussed: "The Tata Hydro-Electric Power-Supply Works, Bombay," by Mr. Robert Batson Joyner, C.I.E., M.Inst.C.E. On conclusion of this discussion the following papers will be presented for discussion: "Road-Corrugation," by Ernest Leonard Leeming, M.Sc.Tech., Assoc.M.Inst.C.E.; "Investigations in the Structure of Road-Surfaces," by Mr. Francis Wood, M.Inst.C.E.; "Notes on Road Construction and Maintenance," by Mr. Thomas Bowyer Bower, Assoc.M.Inst.C.E.

THE SHEFFIELD ASSOCIATION OF METALLURGISTS AND METALLURGICAL CHEMISTS.—On December 3, in the Assembly Room at the Royal Victoria Hotel, at 7.30 p.m., a paper will be read by Dr. W. Rosenhain, F.R.S., entitled "Plastic Deformation in Metals."

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, December 4, at 8 p.m., at the Royal Institution, Colquitt-street, when a paper will be read by Mr. R. W. Allen, C.B.E., M.Inst.C.E., M.I.Mech.E., entitled "Air Supplies to Boiler Rooms."

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, December 4, at the Royal Society of Arts, John-street, Adelphi, W.C. 2, when Mr. A. E. Berriman will read a paper on "Analyses of Some Engine Tests."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 5, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. "The Supply of Single-phase Power from Three-phase Systems," by Professor Miles Walker, D.Sc., member.

THE LONDON ASSOCIATION OF FOREMEN ENGINEERS.—Saturday, December 7, at 7 p.m., at Cannon-street Hotel, London, E.C. Annual meeting, election of officers, &c.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Owing to the General Election having been fixed for the day following that of the December meeting of this Institution, no meeting will be held on December 13. The next meeting of the Institution will be held on January 24, when a paper on "Electric Welding," by Mr. T. T. Heaton, will be presented.

MOTOR TRADE EXHIBITIONS.—The Society of Motor Manufacturers and Traders has decided to organise forthwith a full series of exhibitions. The annual Touring Car Exhibition will be held at Olympia in November, 1919. This, as usual, will include in addition to motor vehicles, full display of tyres and accessories and components. The series of International Aero Exhibitions, which was commenced by the society in 1909, will be forthwith resumed. The pioneer work of the society in this respect proved of great national value in 1914. The next Commercial Vehicle Exhibition is likely to attract greater attention than those prior to the war, in view of the important part which motor transport must play in reconstruction. Also, there is likely to be combined with this exhibition a display of motor tractors, and possibly other forms of agricultural motor. Another branch of the motor industry represented in the society is the marine.

THE LATE MR. EDMUND SHARER.—We regret to have to announce the death, which occurred at his residence at Gosforth, Newcastle-on-Tyne, on the 21st inst., of Mr. Edmund Sharer, shipbuilder, late of Scotstoun House, Glasgow, and up to a few years ago, shipyard director at the Dalmuir naval construction works of Messrs. William Beardmore and Co. Mr. Sharer was a native of Sunderland, but was of Scottish parentage; he was 62 years of age. He received his training in shipbuilding at the works of Messrs. Robert Duncan and Co., Port Glasgow, and was afterwards a partner in businesses in Sunderland and Howdon-on-Tyne. He was appointed in 1893 shipyard manager to the Fairfield Shipbuilding and Engineering Company, Govan; in 1900, when Messrs. William Beardmore and Co. purchased the works of Messrs. Robert Napier and Sons, Govan, he was appointed their shipyard manager. In this capacity, Mr. Sharer moved with the firm from Govan to Dalmuir and was largely responsible for the laying out of the new works at the latter place. Mr. Sharer was responsible for the construction of many notable naval and mercantile vessels. He was a member since 1894 of the Institution of Naval Architects.

THE SANDBERG PROCESS OF HARDENING STEEL RAILS.

THE SANDBERG SORBITIC STEEL COMPANY, LIMITED, LONDON.

(*For Description, see Page* 625.)

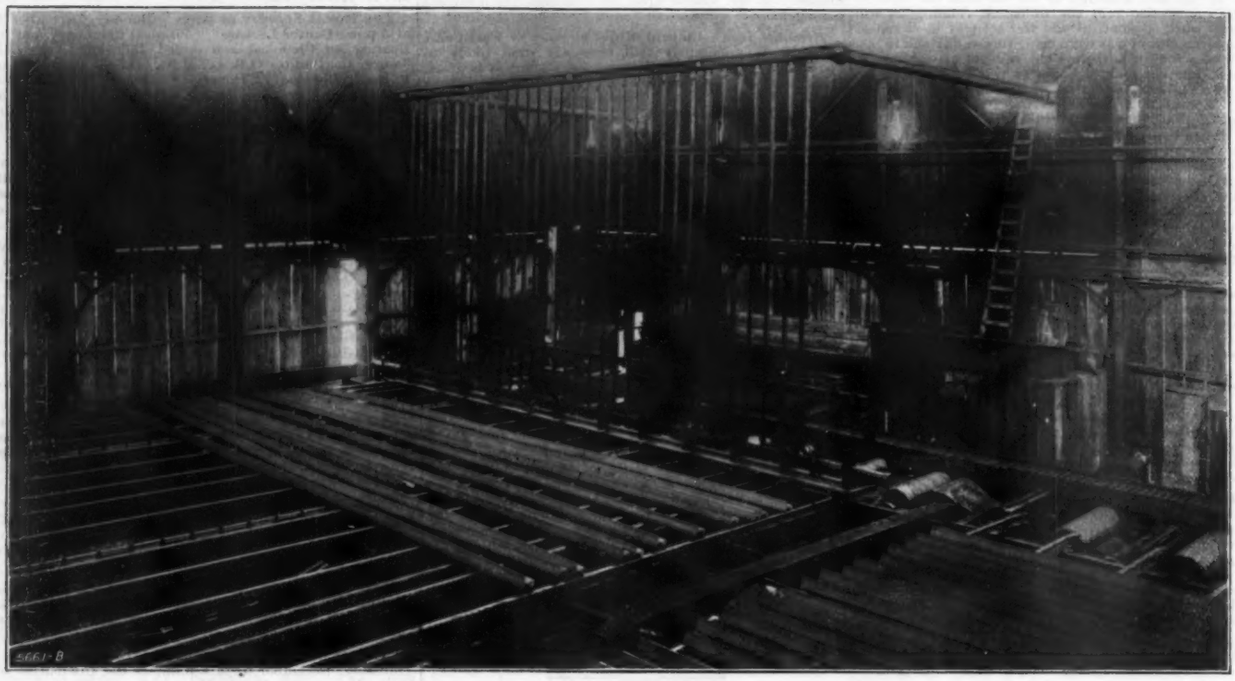


FIG. 1. RAIL HARDENING PLANT AT SPARROW'S POINT WORKS, U.S.A.

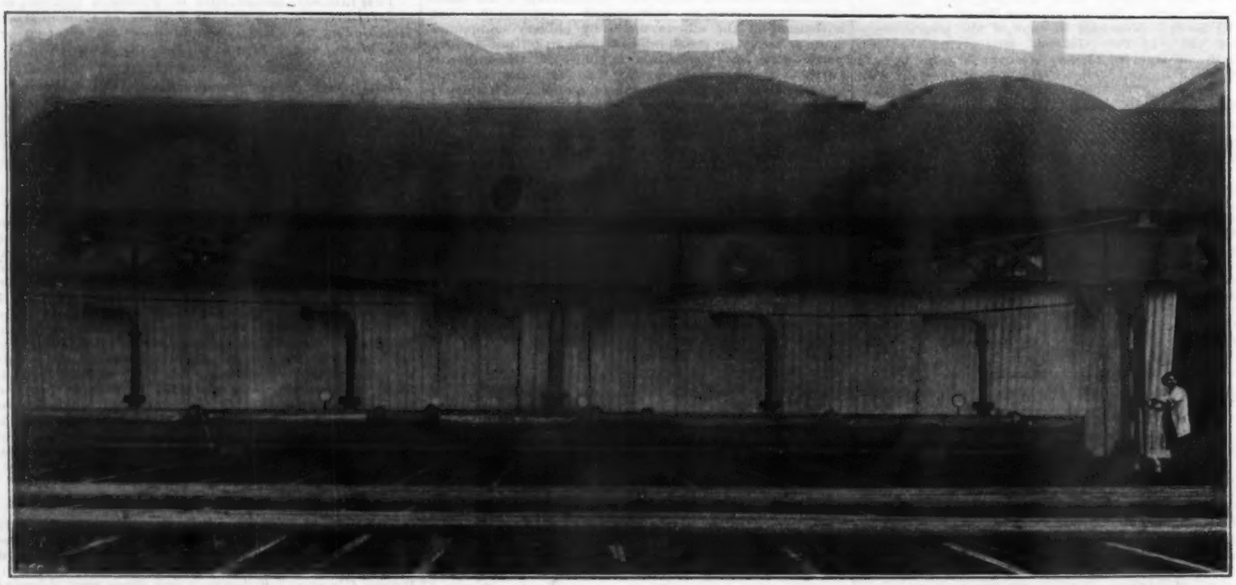


FIG. 2. RAIL HARDENING PLANT AT THE DOWLAIS WORKS.

NON-FERROUS METAL INDUSTRY ACT, 1918.—The committee appointed by the Board of Trade under the chairmanship of Sir Dudley Stewart-Smith, K.C., to consider applications for licences under the Non-Ferrous Metal Industry Act, 1918, have reported to the Board of Trade that the total number of applications received up to October 4 was 1,575, including a considerable number of cases in which it appeared that the trade carried on by the applicants was not of the kind falling within the Act. The number of licences issued up to October 4 was 901. Since that date further rapid progress has been made, and the number of outstanding applications is now very small.

THE PROLONGATION OF THE STEEL UNION.—The agreement of the German Steel Union expires with the end of the present year, and various attempts have been made at forming a new Union under altered conditions or, in any case, with a view temporarily to renew the old agreement. After protracted negotiations, six months grace has been provided for under considerable pressure from certain quarters. This result has only been attained subject to diverse restrictive conditions as far as several works are concerned. Thus the Burbach-Eich-Düdelingen group, most of whose shares are held by foreigners, has only joined, subject to having the right to leave the Union three months after the conclusion of peace, provided peace is concluded within the term of the new temporary agreement, and others have made similar stipulations. The United König and Laura Hütte joined on the condition that their special demands with reference to the Silesian Mining Company should be arranged later on. The George-Marine Mining and Iron Works Union insisted upon further time, until November 15, before giving a final answer. All the works of the Union are agreed, that free sale in any case cannot begin until December 1, 1918, should no final and unanimous agreement be arrived at by November 15 in regard to the provisional prolongation. It was thought that this prolongation would have to be adopted—but many things have occurred in Germany since our correspondent wrote the above information.

RECENT HARBOUR AND DOCK WORKS AT SINGAPOR

MESSRS. COODE, MATTHEWS, FITZMAU ND WI

(For Descrip Page 6

Fig. 13. Laying Reinforced Concrete Work.

Fig. 14. Block Yard, showing Reinforced Concrete Trusses under Construction.

OR STRAITS SETTLEMENTS; TELOK AYER RECLAMATION.

ZMAURICE AND WILSON, MM.INST.C.E., ENGINEERS.

(Description Page 603.)

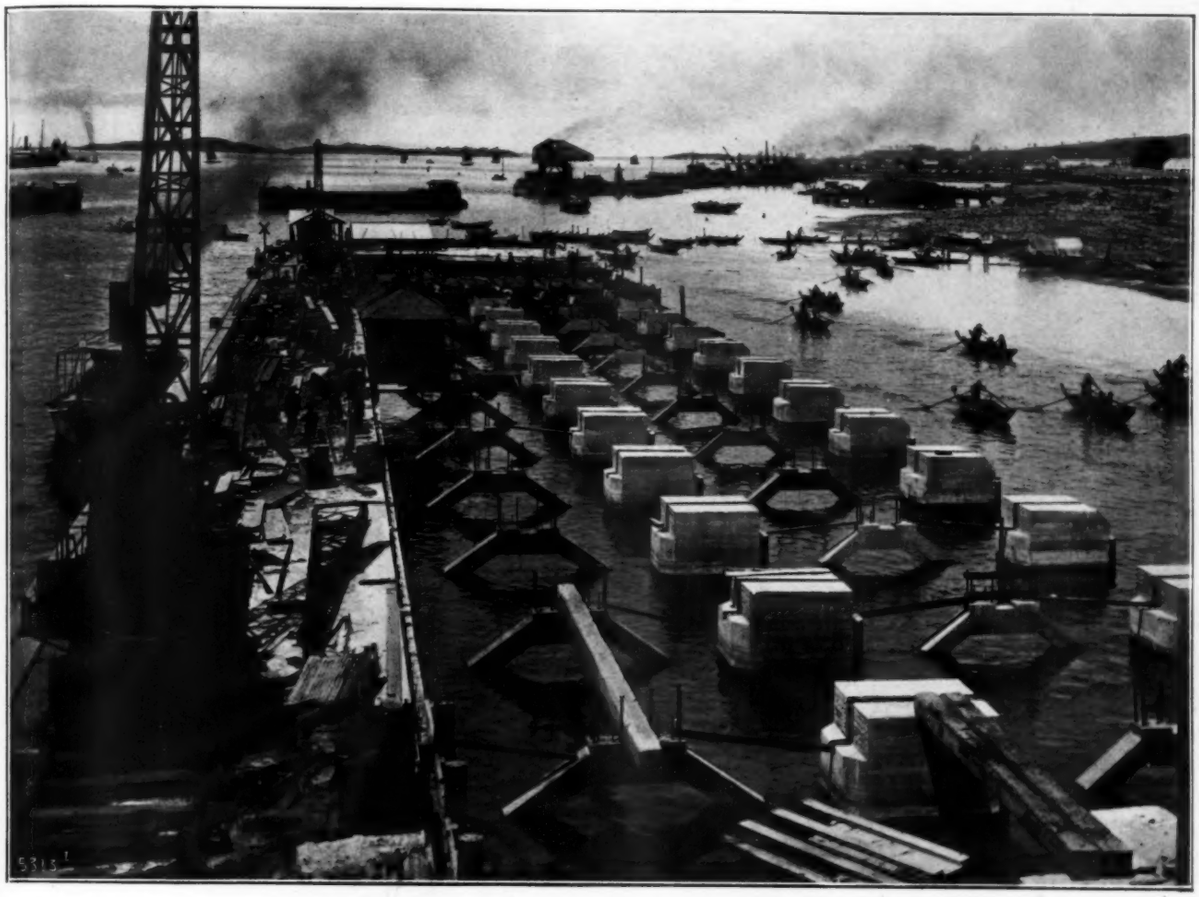


FIG. 15. NORTH PIER, SHOWING PIERS AND TRUSSES IN POSITION.

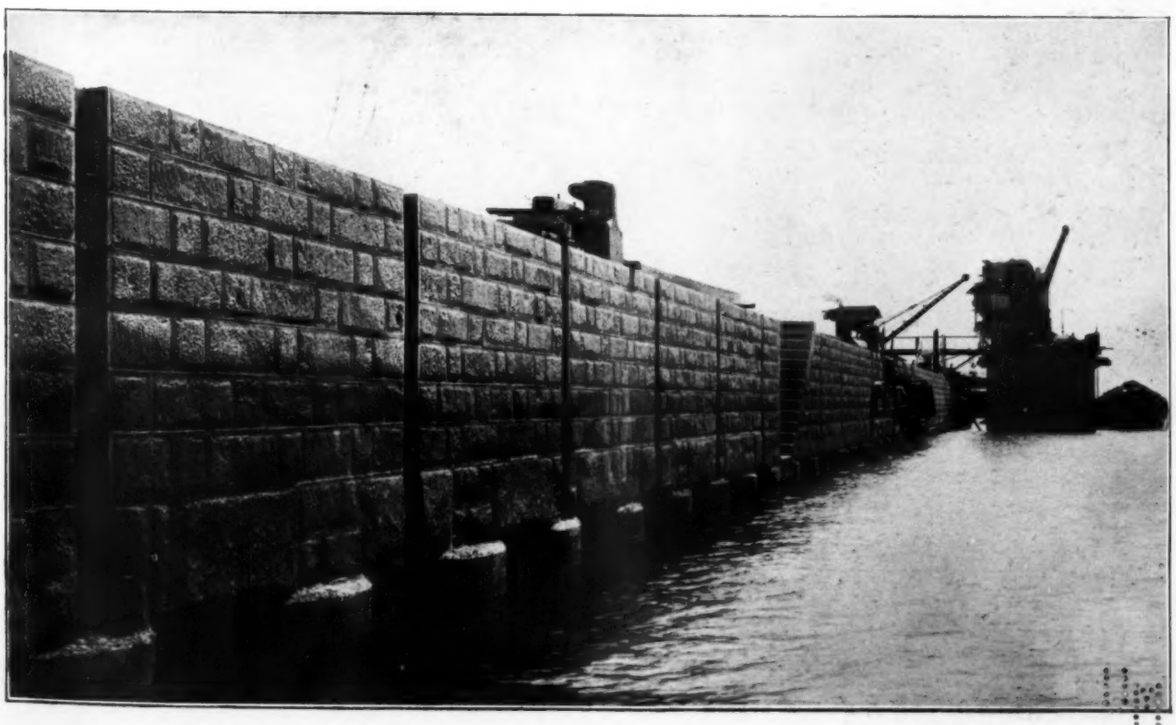


FIG. 16. QUAY FACE.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3068 and 8598 GERRARD.

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With a Two-Page Plate of RECENT HARBOUR AND DOCK WORKS AT SINGAPORE STRAITS SETTLEMENTS; TELOK AYER RECLAMATION.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 615.

ENGINEERING.

FRIDAY, NOVEMBER 29, 1918.

POWER STATION PROBLEMS.

THE discussion last week at the Institution of Electrical Engineers on Mr. J. H. Shaw's paper on "The Use of High-Pressure and High-Temperature Steam in Large Power Stations," was perhaps a little disappointing. In the few remarks made there was little reasoned criticism of the engineering aspects of the problem, though the author's monetary balance sheet did not escape challenge. Few proposals for important changes in practice would, however, continue to prove attractive, if judged on the basis that every possible disadvantage is to be estimated at a maximum and every favourable prospect at a minimum. Such a policy is often urged as the only sound and safe one; but if generally adopted here, it would render this country entirely parasitic on alien thought and enterprise. We have had experience of this in the electrical trades in past years, where municipalities would neither venture on new departures themselves nor allow others to do so, but waited until the pioneering work had been done abroad and then gave their orders for equipment to foreigners on the ground that our manufacturers lacked the requisite experience. Fortunately this reluctance to shoulder risks is not universal, and Mr. Shaw mentioned in his paper that Messrs. Babcock and Wilcox have now in hand boilers designed for a working pressure of 475 lb. per square inch and a total steam temperature of 700 deg. F.

These boilers are, we presume, intended for a certain large power station, for which the firm supplying the turbine machinery has given a record guarantee. One well-known turbine engineer holds that by the use of steam at high pressure and superheats and by certain innovations in the use of this steam, it will be possible to generate one brake horse-power for a net expenditure of 8,000 British thermal units, which is about as good a figure as is obtainable with large gas engines.

The gas engine, or rather internal-combustion engine, found two advocates at the meeting. In the one case the speaker asserted that the efficiency of the Diesel engine was over 42 per cent. In the discussion on Dr. Diesel's paper at the Institution of Mechanical Engineers, in 1912, however, Sir Dugald Clerk claimed that such high figures were entirely fallacious, being obtained by neglecting part of the negative work inherent in the cycle, and pointed out that the brake thermal efficiency of the Diesel engine tested by Mr. Longridge in 1905 was only 29½ per cent., whilst the Mirrlees Diesel engine tested shortly before the occasion of his remarks yielded a maximum brake thermal efficiency of 31½ per cent. These figures, Sir Dugald observed, were not higher than were realisable with gas engines. Even were the internal-combustion engine much more efficient than it actually is, it would still in any pattern yet devised be ill adapted for adoption in really large power stations, owing to questions of cost and of space occupied. The maximum piston speed of large reciprocating engines is of the order of 1,000 ft. a minute, whilst large steam turbines have been built in which the blade tip speed is nearly 1,000 ft. a second. The consequent difference in the space occupied per kilowatt of output is enormous, since the electric generator, as well as the prime mover, benefits by the higher speed. A slow-speed generator, of course, costs much more per rated kilowatt than a high-speed one and occupies relatively much more space.

In estimating the possible advantages of extra high-pressure steam as compared with steam supplied at a lower pressure but at the same temperature, Mr. Shaw uses as his criterion the adiabatic heat-drop available in the two cases. This procedure is not wholly legitimate. No turbine has a unit hydraulic efficiency and the real effective thermodynamic head is therefore greater than the adiabatic heat-drop. The ratio of the two is the reheat factor. If, as is assumed, in the text books, the steam expands through a turbine in a condition of thermal equilibrium, the reheat factor will be very materially higher for the superheated field of the Mollier diagram than for the saturated field. With a given total temperature the amount of superheat is greater the lower the pressure, and hence on this basis the lower pressure supply will benefit by a higher average reheat factor than will extra high-pressure steam. As a result, the true gain will, on the theory in question, be somewhat less than if it were proportional to the adiabatic heat-drop. If, however, the views recently put forward in these columns are correct, and the steam does not attain thermal equilibrium until the condenser is reached, the reheat factors for the extra high pressure and for the medium pressure steam will not materially differ, and a better case can be made out for the adoption of extra high-pressure steam. Basing his estimates on the adiabatic heat-drop, Mr. J. H. Shaw concludes that with a 50 per cent. load factor the overall coal consumption at a large power station can be reduced to 2 lb. per kilowatt-hour, using steam at 500 lb. absolute superheated by 268 deg. F., whilst with steam supplied at 215 lb. absolute superheated to 300 deg. F. he considers that the corresponding figure will be 2·18 lb. of coal. There is thus a saving of about 9 per cent., the importance of which is increased by the recent rise in the price of coal, which will probably be to a considerable extent permanent.

In making this estimate, Mr. Shaw assumed a boiler efficiency of 77½ per cent., and this figure was criticised at the meeting. One speaker declared that it was not attained at any power station in the United Kingdom, and that the usual figure was more like 65 per cent. We believe that the assertion that 77½ per cent. is not attained here is inaccurate, as we understand that at one of the North-East Coast power stations the year-in-year-out boiler efficiency averages some 83 per cent., but it is no doubt true that, in general, boiler efficiencies are nothing like so great as they ought to be. This fact constitutes an additional argument in favour of the super-power station, since in large-scale operations it is easier to provide for a really skilled staff, specially charged with the promotion of fuel economy. The margin of possible gain is, on the average, probably considerably higher in the boiler-house than in the generator hall.

This is true not merely as regards a reduction in fuel expenditure, but still more so in respect to economy of space. In this matter boiler makers have lagged far behind their colleagues responsible for the generating machinery. Mr. Shaw stated that at Bradford it is proposed to generate 45,000 kw. in a space previously occupied by sets with an aggregate capacity of 4,000 kw. The ratio of gain is thus 11 to 1. Indeed the modern turbo-generator is little more than a mere annex to an immense battery of boilers.

Now it has been proved that 34 lb. of steam can be generated from 1 sq. ft. of heating surface, and with a very high efficiency. In actual practice with ordinary water-tube boilers working at maximum economy the amount of steam generated does certainly not exceed some 6 lb. per sq. ft. of heating surface. The ratio between this figure

and that which has been proved by Professor Bone to be technically possible, is nearly 6 to 1, thus promising a ratio of gain of the same order as has followed from the supersession of the reciprocator by the steam turbine. It is quite possible, even likely, that many difficulties may have to be surmounted in rendering the surface combustion system suitable for large power-station plants. As is well known decades of experiment were required to make a commercial success of the ammonia soda process, and also of many catalytic reactions now largely adopted industrially. To effect any such change in the boiler-house as the turbine has effected in the generator hall would seem to involve a revolution rather than a reform. The essential fact is that actual experiment has proved that at any rate under laboratory conditions the output of steam per unit of space occupied can be increased several-fold. Sooner or later, judging from past experience, the translation of this experimental result into current commercial practice will be effected, and it is to be hoped that the task of surmounting such difficulties as may be involved will not be left to foreign brains and foreign enterprise.

In comparison with the savings possible in this direction, those offered by the adoption of high-pressure and high-temperature steam seem almost trivial, but it may well turn out, that they are for the present at any rate, more easily attainable. Some difficulties are sure to be encountered. We have, for example, not much in the way of reliable data, as to the strength and endurance of our ordinary metals at the temperatures proposed. Cases were mentioned at the meeting in which steel studs, used to couple up flanges exposed to the relatively moderate temperatures now customary, proved to become as brittle as carrots after two or three years' service. In another case steam pipes were found to have suffered similarly. Much, however, has been learnt during the past five years as to the metallurgical problems involved, and their solution will be less difficult now than it would have been in pre-war times.

In one part of his paper Mr. J. H. Shaw seemed to accept a certain thermodynamic fallacy which appears to be somewhat widely held. He observes that "It may be possible in the future to eliminate some of this loss (to the condenser) by the use of a substance other than water which will require less heat to convert into a gas." If by this is meant that a low latent heat would be an advantage the precise contrary is the case. The larger the latent heat the greater the proportion of heat which is transmitted to the working fluid at a high temperature and the nearer the approach to the ideal Carnot engine, in which the whole of the heat is added to the working fluid at the highest temperature attained in the cycle. The Carnot engine is, of course, that of maximum efficiency, and one of the most striking of Carnot's results is his proof that this efficiency is independent of the physical properties of the working fluid used. That this latter theorem does not hold, in the case of actual turbines, which are never friction free and are consequently not thermodynamically reversible, was pointed out in our columns nearly two years ago,* where it was shown that a mercury vapour turbine would have a higher reheat factor than a steam turbine operating with the same hydraulic efficiency and the same pressure ratio. The advantage of the mercury vapour in this regard has, however, nothing to do with its lower latent heat, but is attributable to the fact that its molecule is simpler than that of steam.

THE MARINE OIL ENGINE IN THE UNITED STATES.

MERCHANT shipbuilding in this country during the last three years has been confined, due to war conditions, to standard classes of vessels in which the equipment has been restricted to long-established and well-tried types of machinery. In the United States of America, the problems of assisting to overcome the large deficit of shipping and of ensuring that the enemy submarine menace should not prove a factor of decisive importance has to be attacked from a somewhat different angle. When consideration is given to the small extent of facilities existing in America prior to the war, the establishment of large shipbuilding yards, with fully-equipped berths and the training of the necessary labour was in itself an undertaking of magnitude even to a country of large enterprises. The project only became a workable proposition ensuring sufficiently early production to effect the balance of tonnage, when bridge-building shops and all other inland works suitably equipped, were brought in to fabricate as many as possible of the parts of vessels these being transported to the shipbuilding yards, there to be merely erected in place on the building slips and riveted up. Similarly in the case of the production of propelling machinery, it was necessary to utilise for the propulsion of the ships so built, every type of standard engine which could be said to be in any way suitable for marine work. With commendable enterprise this course has been followed and, in regard to internal-combustion engines, American ships are being equipped with almost every known type of oil engine, utilising in consequence in the case of several types various means to reconcile conditions of maximum propeller and engine efficiency, such as mechanical gearing and electric transmission.

The types of engines being fitted include semi-Diesel engines, both two and four-cycle, direct reversing and with reverse gears, Diesel engines, two and four-cycle, land trunk piston and marine crosshead designs, engines of high speed of revolution with mechanical gearing, or electrical reduction between the engine and the propeller, and the usual slow-speed direct-coupled motors. The powers up to which the marine oil engine is being built at present in America are relatively small, 200 h.p. per cylinder being the maximum of which we have record. The many and varied types of machinery, however, which are now at sea in the American marine, or shortly will be tried out, will give to the American marine engineers a very clear insight into the problems associated with the future developments of this industry, and will provide much useful data on which to base future designs.

The two most interesting types of installation will probably be regarded as the Diesel engine geared down to the propeller shaft and the electric system of transmission. The fact that these systems are being used in conjunction with the Diesel engine is not necessarily a pointer for future guidance when conditions return to normal, but is rather the outcome of immediate exigencies, and results from efforts to utilise as many as possible of the existing types of engines, manufacturing plants, with complete sets of jigs, fixtures and tools as are immediately available.

The geared machinery recently constructed is the first marine geared Diesel engines, we believe, since some early and small-powered paddle vessels were so fitted for the Volga trade, and records of performance with these larger sets should be interesting. The main Diesel engines in one case are of the well-known type developed by Messrs. Willans and Robinson, of Rugby, and built by their sole American licensees, the Dow Pump and Diesel Engine Company, of Alameda, Cal. Extra cams, &c., have been added to make the engines reversible. The six working cylinders have a diameter of 12 in. and a stroke of 18 in., and develop 320 brake horse-power at 250 r.p.m. The reduction gear reduces the speed of revolution from 250 r.p.m. of the engine to 100 r.p.m. for the propeller. The principle of the reduction gear can be said to be accepted by marine engineers, and has a number of advantages in connection with the application of Diesel engines to marine propulsion. A certain saving in weight and space will accrue. The difference in efficiency, or in fuel consumption between a slow-running Diesel engine and a relatively high-speed engine is very small. In the past marine Diesel engines have generally been designed to run at a somewhat higher speed of revolution than is compatible with maximum propeller efficiency for the type of vessel in which they are installed, viz., some 110 r.p.m. to 140 r.p.m., whereas reciprocating steam engines for this duty would run at some 70 r.p.m. to 85 r.p.m. This higher speed with Diesel engines has been adopted to reduce overall size and weight, so to lessen cost and also to give to a relatively and inherently inflexible prime mover that degree of flexibility required for manœuvring, towing, &c. In this light it is quite probable that an installation with high-speed Diesel engines, some 300 r.p.m. or so, with reduction gearing, will, owing to higher propeller efficiencies, give for the same speed of ship as good an overall efficiency measured in knots run per ton of fuel consumed, as the usual slow-running direct-coupled type. The case is not altogether analogous to that of the geared turbine, where turbine efficiency is the chief consideration, and, furthermore, with a turbine the question of turning moment does not arise. The turning moment with these six-cylinder, four-cycle engines will have a minimum cyclic variation of about 100 per cent., and when the engine is commencing to fire or when, as may occur, one or perhaps two main-power cylinders are cut out, the turning moment will be still less regular. A fairly heavy flywheel of course is fitted to damp out cyclic variations in speed.

The question of the ability of mechanical gearing to stand up to its work under conditions of uneven turning moment, is the principal one that can be raised in connection with this application of gearing, and the results of practice at sea will be eagerly awaited. If results are satisfactory a considerable extension of application of this means of reducing the revolutions of the Diesel engine to give high propeller efficiency and permit of a smaller and lighter engine, can confidently be anticipated.

The electric system of power transmission with which we are informed a large number of American motor ships are being fitted, does not necessarily portend advantages for the Diesel electric drive, but means that electric machines and standard generator driving Diesel engines are being pressed into service to engine the ships built, or building. This type of installation has undoubted advantages similar in certain directions to the geared Diesel drive, in that a relatively high-speed engine can be utilised and, furthermore, with the electric system, the main power units may be situated as is most convenient to the particular design of ship. It is only necessary that the main propelling motors drive directly on to the propeller shafts. Electric driving of the auxiliaries gives advantages of considerable economy over the usual steam-driven machines supplied from a donkey boiler. This economy is maintained due to the fact that one or both of the main generators—there will generally be two such—can be utilised in port to generate the relatively large current required for the cargo-handling auxiliaries. Two further advantages are that, first, the complications of gear required to reverse the direction of rotation of the main Diesel engines are eliminated and, secondly, the engine is primarily a constant-speed engine, so that variable speed running and manœuvring gear need not be fitted. Those with experience of the operation of internal-combustion engines will readily admit that internal-combustion engines are fundamentally constant-speed engines. Flexibility demands compromise and often complication. The only electric Diesel drive that has been tried out at sea, the motor-vessel Tynemount, was unfortunately unsuccessful due to various causes, quite unconnected, so far as is known, with the main principles of electric transmission which recently has gained so much ground in the United States of America, in conjunction with steam machinery. With this electric drive the saving in weight and space will not probably be so great as with the mechanical gearing, and the cost inevitably must be higher. The possibility of eliminating the valve reversing gear on the main engines, the great saving in storage of compressed air usually required to give ample capacity for manœuvring of the main engines, and in means for compressing that air, together with the perfect flexibility possible of attainment with the electric drive, make this proposition one of considerable attractiveness.

The foregoing are the principal innovations being adopted in America under the unique conditions operating at the time. Quite apart from such interesting examples, the great number of marine oil engines being turned out in America should be pointed out. Many new factories have been established and existing works have been doubled and trebled in capacity.

* ENGINEERING, January 12, 1917, page 35.

It is earnestly to be hoped that, the moment the situation permits, British designers and constructors will be permitted to make up the leeway that regrettably, but unavoidably, has been lost, and will, in such case, attack the various problems concerned with the development of the marine oil engine with a rigid determination to regain their position.

THE MOTOR FUEL PROBLEM.

EXPERTS in different industrial branches would, on inquiry, probably draw up different lists of key industries. None of them, however, would omit to class the industry of internal-combustion motors among the most important key industries, and this not only because these vehicles are still wanted in the Army. The war has so thoroughly changed all industrial foundations—quite apart from political and national considerations—that it will for some time to come be difficult to dismiss it from our minds when estimating the future. What was necessary, possible and profitable during the war, may become undesirable and impossible in normal times. Some of the special uses of motors, uses which have rendered their rapid perfection possible, may vanish. But the motor will conquer other fields in which it had before the war already obtained a firmer footing in other countries than over here. Authoritative statistics are not available at present. To characterise, however, the importance of the industry Mr. W. R. Ormandy, D.Sc., when discoursing on the Motor Fuel Problem before the Institution of Petroleum Technologists last week, stated that he estimated the wages paid annually in this country for the manufacture of motor vehicles at more than 10,000,000*l*. That estimate entirely disregards accessory industries connected with light alloys, springs, rubber, tyres, leather, &c., some of which may almost be said to stand and fall with the motor as matters are now. The United States are credited with 5,500,000 motor vehicles, half of which serve for farming, forestry, mining, stock raising, fisheries, &c. Motor transport and agricultural developments are inseparably linked. In the future aeroplanes will need much motor fuel. A Handley-Page machine alone consumes as much as 40 motor cars per hour, Dr. Ormandy believes, and even without the war the country would have wanted 200,000,000 gallons of motor spirit per annum by this time. Where is the fuel to come from?

America produces some two-thirds of the world's petrol from natural oil; but it has long felt the pinch, and though new petroleum fields are opened, old ones dry up, and an actual world shortage will have to be met sooner or later. What other fuels can be utilised in internal-combustion engines? Dr. Ormandy distinguished them as solid, gaseous, liquid. Solid coal can be gasified in the producer, but bituminous coal is hardly suitable for such purposes. The last word has not been said regarding steam-driven motors, however; the Clarkson motor omnibus has so far been run on paraffin, but Mr. Clarkson has, according to Mr. Ormandy, obtained promising results with coke-fired boilers. As regards charcoal, the woody lignites of Ireland may give a suitable fuel for producers. But though solid fuels may be adapted to serve as indirect fuel for stationary engines and heavy portable motors, they cannot play an important part. That gaseous fuel, compressed town gas, can be burnt in motors, has been shown; 250 cub. ft. of gas are considered equivalent to a gallon of petrol; the introduction of suitable containers would render another auxiliary source available; but it would not do more.

The more important liquid fuels are petrols, paraffin oils for marine engines, &c., and fuel oils for Diesel or semi-Diesel engines. Substitutes for petrol are gained by coal distillation. By-product ovens yield from 1½ gallons to 3½ gallons of liquid fuel per ton of coal carbonised. From the gas of gas works similarly 1 gallon or 2 gallons of benzol and toluol are obtained, and post-war conditions, Mr. Ormandy suggested, might yield some 50,000,000 gallons per annum. If central electric power stations should take the expected development in combination with producer-gas plants, however, that figure would be smaller. Shale oils help also, and the sulphurous shale deposits from Norfolk down to Dorset might be utilised; but that again would be a minor factor. The next available source, alcohol, could certainly be produced in almost unlimited quantities; but the heat of combustion of alcohol was relatively low, alcohol was not readily inflammable, and the advocates of alcohol-fuel had prejudiced their own cause. In any case little had been done by the public, the motor users, to whom motor manufacturers left that problem, and the Government had been guided by the experts of the Excise Department. Alcohol could, and was, produced in the first instance from sugar molasses by fermentation, and there was no reason why sugar beet crops should not thrive here. If grain-raising were to be pushed, in fact, roots would have to be planted in rotation, and sugar-beet root might profitably replace turnips and mangolds; Dr. Ormandy seemed to forget that sugar-beet roots require heavy manuring. Sugar-alcohol, however, cannot directly supply the Empire's motor fuel, even if local industries, like the sugar manufacture from the Indian mowrah-tree flower, were fostered.

But there are indirect sources of sugar. By digestion with alkalis or acids both starch and cellulose are converted into fermentable sugars. The English glucose is mostly starch-sugar, and quite an important article as such. The most common source of starch is the potato. In Germany, Dr. Ormandy rightly pointed out, alcohol is not produced from potatoes because they form the cheapest raw material available, but because their use favours home agriculture. Hundreds of square miles of sandy soil, notably in the eastern part of Prussia, sustain an agricultural population, which is occupied in the fields in summer, is busy in the distilleries in the winter, and obtains a valuable cattle food in the distillery residue (schlempe). The special potatoes for the distillery fetch about 22*s*. per ton in Germany; that money, however, would not alone keep the people, if it were not for the work and other profits drawn from an agriculturally poor soil. The Prussian Government has wisely encouraged potato farms and local distilleries which are the joint property of small peasants or owned by the great landlords. The question, however, is not really capable of such brief summation as Dr. Ormandy attempted. He did not overstate his case, however, and he warned his hearers against the optimistic estimate which Mr. R. W. Tweedy had given in a pamphlet on industrial alcohol. The alcohol yield of the best special potatoes does not exceed 20 gallons or 25 gallons of 95 per cent. alcohol per ton of potatoes, and Ireland could not produce 150,000,000 gallons of alcohol from 2,500,000 tons of potatoes, certainly not if the potatoes were to be sold at 3*l*. 10*s*. per ton to the distillery. For warmer climates, in Australia and Africa, maize yielding 75 gallons of alcohol is a much more promising material, of course.

Successful experiments on the conversion of cellulose into sugar by the Classen process have recently been made in the United States, on a large scale, Dr. Ormandy mentioned; but he did not give particulars, except that he spoke of a yield of 30 gallons or 40 gallons of commercial alcohol per ton of wood. How these figures compare with the 10 per cent. of 95 per cent. alcohol which the Ewen-Tomlinson process is said to yield, we do not know. The difficulties lie mainly in the construction of suitable vessels not attacked by hot acids under pressure. The sulphite wood-pulp residue treatment seems, however, really to have risen from the experimental stage, if Sweden has works producing 4,000,000 gallons of alcohol per annum in operation, and works for 3,000,000 gallons under construction; Norway is credited by Dr. Ormandy with works for 4,000,000 gallons, the strength of the alcohol not being stated. Sulphite wood pulp is the residue from paper-making with calcium or magnesium sulphite (instead of the more expensive caustic soda). The logs are sliced at right angles to the fibre and boiled for 5 hours or so at 2 atmospheres pressure in vessels lined with lead; the sulphite is prepared in Glover towers or in vats. The sulphite liquor has so far practically been a waste product; there are difficulties about neutralisation to start with, and it would be interesting to know how alcohol is obtained from the liquor, though it generally contains some sugar. There is finally the synthetic production of alcohol, from calcium carbide *via* acetylene. Such processes are certainly worked in Germany and by the Lonza Company in Switzerland, as we noted some time ago; with what results is not yet known.

With the question of the suitability of alcohol as motor fuel we have dealt on other occasions. Thousands of alcohol motors, chiefly stationary for agricultural purposes, engines working with long stroke and high compression and fitted with preheaters for starting, were working on the Continent before the war. The higher thermal efficiency of these alcohol motors balances the lower heat value of the fuel, and the much-dreaded corrosion of the cylinders can be averted, as Continental experience and the experiments carried out by the *Auto-car* prove. That alcohol can also be used as fuel mixed with benzol, in the ratio of 2 : 1, *e.g.*, without calling for more alteration of the engine than required for preheating the air supply and slightly enlarging the jet, is likewise established; motors run more smoothly on such mixtures than on petrol according to Dr. Ormandy. There is, of course, need for further research, as to viscosity, vapour tension, the admissible percentage of water, and the best proportions of mixtures of benzol, alcohol and water, and also alcohol-benzol-ether mixtures. Lubrication problems may also arise. The use of paraffin oil mixed with petroleum caused trouble in the bearings, and Dr. Ormandy found out in experimenting together with Mr. Lester that, when petrol is used, a certain amount of this fuel gets into the crank-case oil and sets up an equilibrium depending upon the temperature of the oil, the amount of ventilation and other factors. Moreover, with paraffin, which has a lower vapour pressure, larger quantities are washed out and retained by the oil spray in the crank-case, so that the viscosity of the lubricating oil is diminished.

The main questions are, however, how the supply and the distribution of an alcohol-benzol mixture, in the ratio 2 : 1, can be secured and maintained. These are largely financial questions, which Dr. Ormandy argues on the following lines. The United States are supposed to have built 1,700,000 motor vehicles (not including motor ploughs, boats, aeroplanes, petrol-driven lighting and pumping sets) during the past twelve months. At the rate of 400 gallons annually these motors would alone consume some 700,000,000 gallons or 2,000,000 tons of petrol; supposing crude petroleum to yield 20 per cent. of petrol, an additional 10,000,000 tons of crude oil would be required to keep the American cars of one year on the road. The world's production of petroleum probably does not exceed 50,000,000 tons per year. The present production of benzol for motors in this country may come up to 50,000,000 gallons per annum; if 100,000,000 gallons of alcohol were also available, the present demand could be met. To double the benzol output of petrol, as we shall see, necessitates that the output of the gas works and the iron and steel trade should be doubled, and the enormous capital involved in these expansions cannot be got into operation as rapidly as the fuel demand is increasing. There is hence no alternative in sight except alcohol. This demand for alcohol is no new fancy, of course. The report of the Imperial Motor Transport Conference of 1913 may be summed up in the words "Develop alcohol fuel," and Dr. Ormandy himself had advocated alcohol in the Automobile Club twenty years ago when petrol was 1*s*. per gallon. An Inter-Departmental Government Committee, of which Sir Boverton Redwood is chairman, is dealing with fuel-alcohol.

We pass to the distribution problem and the gas and iron works. The production of benzol depends upon gas works and coke-oven works. The gas works will grow, and hence be able to produce more benzol; but they will also have to utilise low-grade coal, and to face many new problems. Dr. Ormandy, we might interpose, seems to presume that the gas companies are willing to go on with stripping the gas; some gas engineers certainly wish to be relieved of this obligation. Coke ovens, the other source of benzol, can only grow together with iron and steel works, and whether they will put down benzol-recovery

plant will depend upon the market value of the benzol. To control the market the petroleum companies will endeavour to obtain possession of the benzol supply. They can rightly claim that they are able to mix the benzol with the petrol and that they possess the organisation necessary for distributing the product. The benzol producers, likewise organised, might dispose of their whole production to the petroleum firms at an agreed price, or on a sliding scale, to be relieved of the distribution worry; but they cannot expect to control the motor fuel market if they supply only part of the total demand. The petroleum companies hold the field apart from the benzol; they are corporate bodies existing for the purpose of making profits. They can also retard the progress of alcohol. Thus the fuel users, the public, will be shorn, unless the Government step in, or the users combine with the motor industry to secure the benzol supply of the country as a national asset. They will combine, Dr. Ormandy thinks, if they recognise the situation.

LITERATURE.

Physical and Chemical Data of Nitrogen Compounds. Specially compiled for use in connection with the Synthesis and Oxidation of Ammonia. Munitions Inventions Department Research Laboratory, University College, London.

By issuing this small quarto pamphlet of 50 pages, supplemented by 47 pages of diagrams, the Nitrogen Products Committee of the Munitions Inventions Department has undoubtedly done a very useful piece of work, and not only for those interested in the synthesis and oxidation of ammonia and in the production of hydrogen, for whose benefit the volume has especially been compiled. In the first instance there are too many people left in this country, who, having secured a good, duly-patented process, which they have watched working smoothly in the laboratory, consider that all they have to do is to lay down plant to deal with kilogrammes and tons instead of with grammes. Expensive installations have been erected within the past few years on the strength of a general, but very defective knowledge of the fundamental scientific principles underlying the process. A glance at the book before us will teach them that their chemists may have to rub up their mathematics to work out the detail, unless somebody else should already have fixed everything plainly in pounds, cubic feet, degrees Fahrenheit, minutes, &c. Our second point will best be understood if we take a definite example from the "Data." No gas, we know, rigidly follows Boyle's law. The volume will be halved when the pressure is doubled, but a pressure of 100 atmospheres will not reduce the volume to 1/100. Tables of constants may give us the exact fraction, but the chemist wants to know, for instance, how many volumes of gas at ordinary temperature he can obtain from a cylinder containing gas at 100 atmospheres, and that he cannot directly read in ordinary tables. The Data tell him that he will obtain, at 16 deg. C., 93·6 volumes of hydrogen, 105·2 of oxygen and 477 of carbon dioxide—the last figure is so great because CO_2 is liquid at pressures exceeding 90 atmospheres, but the other deviations are too large also to be neglected in technical practice as is commonly done. Another example: In the synthesis of ammonia, 3 volumes of hydrogen are to react at, say, 200 atmospheres with 1 volume of nitrogen. How must we proceed to obtain a final correct mixture of 200 atmospheres? We might mix the gases at ordinary pressure and compress the mixture. It will be more convenient, however, to start with one gas, compress it and then admit the other gas into the cylinder. The Data show that this can be done by adjusting the nitrogen pressure to 44·5 (instead of 50) atmospheres, and then filling up with hydrogen until the cylinder gauge marks 200 atmospheres. We might have calculated that ourselves; but few of us are fond of these "simple" calculations, in which certain quantities have a puzzling habit of changing over from the positive to the negative side.

Questions of this kind and more intricate problems frequently arose in the Research Laboratory, and the respective information on constants and equilibria had to be collected from many different, sometimes hardly accessible, sources. In order to facilitate the work of the members of the staff, occupied in the allied but distinct sections of synthetic ammonia, oxidation of ammonia and preparation and purification of hydrogen Dr. J. A. Harker, F.R.S., Director of Chemical Research, started upon a critical examination of the available data and upon compiling them in a handy form. That, of course, would be an arduous task for a man fully at leisure, and the volume before us is the outcome of the joint work of the staff, Dr. G. W. Todd, the Physicist to the Laboratory, and the heads of the sections, Doctors H. C. Greenwood, J. R. Partington, E. K. Rideal and H. S. Taylor, who had the further assistance of Mr. C. Cochrane, M.A., especially in the compilation of the first section of general gas data. Though few of the values presented depend upon actual determinations carried out in the Laboratory, many of the tables and curves given embody the results of special investigations and computations. Mr. Cochrane's notable deviations from Boyle's law were, for instance, comfirmed by experiments in the Laboratory. The graphic form of presentation adopted will be found convenient and sufficiently accurate for most purposes; in conformity probably to the large scale of the diagrams a large type has been chosen for the tables. All the tables and their symbols are well explained in a manner which might be imitated by some other compilers and editors; hazily explained symbols are responsible for a good deal of mischief. The explanations in most cases are brief general and mathematical statements of the respective laws; the ways in which calculations are performed are clearly indicated.

The first section on Gas Data deals with P V relations, Van der Waal's constants and critical data, density, viscosity and its temperature coefficient for gas mixtures (Sutherland), latent and specific heat and thermal conductivity. There are only three specific heat figures for water in this section, those of Holborn and Henning, Pier and Makower (the γ ratio of the two specific heats), all for 100 deg. C. We mention this as the book—we see from the preface—is only to be regarded as a first instalment, and criticisms are invited. The second section on Ammonia contains among other tables, the total and partial vapour pressures of anhydrous ammonia, and its aqueous solutions, its solubility, &c., also useful curves showing the temperatures and pressures at which condensation of ammonia should begin in mixtures of various concentrations and on the percentages of ammonia theoretically removable by cooling the mixtures at pressures up to 200 atmospheres.

In the Nitric Acid Data, Dr. Todd and Captain Partington exemplify in detail how the velocity of the oxidation of nitric oxide NO by atmosphere oxygen to the peroxide NO_2 can be calculated; this question is of considerable importance to the designer of reaction towers, standard designs of which are still wanting, and the method of conducting such calculations is not sufficiently explained either in text books or in special papers. In technical practice, both British and foreign, the old rule-of-thumb is still supreme as to tower design. The curves of the data are based upon the experiments of Lunge and Berl. Since the Data were compiled, particulars of the redetermination of the oxidation of NO have been published both by Bodenstein at Hanover (working at low pressures and temperatures up to 90 deg. C.) and by Briner and Fridöri at Geneva (technical pressures up to 60 deg. C.). The figures of Lunge and Berl are confirmed by these investigators; it is found that the reaction velocity decreases by about 15 per cent. with a temperature increase of 10 deg., and that N_2O_2 is in equilibrium with NO and NO_2, but is rapidly destroyed by any caustic alkali or concentrated sulphuric acid present. The reaction NO + O is itself practically instantaneous; the point is to bring the gases in contact. The redeterminations hardly affect the curves of the Data.

The fourth section is on Hydrogen Purification, the water-gas equilibrium and the equilibria of the allied reactions between carbon and carbon oxides, oxygen, hydrogen and further, iron oxide and methane; some dissociation constants are also given. On page 34 the formula for the dissociation of water vapour contains the fraction $\frac{x^3}{(2+x)+(1-x)^2}$; the + in the denominator should be a sign of multiplication, as Dr. Harker has pointed out to us; similar formulæ are correctly given in other parts of the book. A fifth section of Miscellaneous Data (heats of formation, of fusion and modification, latent heats, &c., conversion tables) will help workers to dispense with other tabular matter in their investigations.

The volume has warmly been welcomed by all who have been able to examine it. It is issued by the Munitions Inventions Department for the general use of official departments as well as of controlled works and manufacturers in general. We mentioned already that the present issue is only to be regarded as a first instalment, and not as a completed work. A further instalment is in preparation, we understand, and similar publications, based on adequate research, of course, might appropriately follow. We hope that the volume will be put on sale so as to be generally available; it will certainly be instructive to advanced technical students as well as to manufacturers.

Works Lighting. By DANIEL H. OGLEY, B.Eng., Lecturer in Electrical Engineering, the Royal Technical Institute, Salford. Illustrated. London: Iliffe and Sons, Limited. [Price 7*s.* 6*d.* net.]

In this climate and latitude for the greater part of the year we have to rely on artificial lighting if we would increase the usefulness of our lives and achieve the full measure of our capacity. It is therefore difficult to overestimate the importance of light from either the humanitarian, or the commercial, standpoint, and a ready welcome should be extended to all who endeavour to utilise the resources of science and of ingenuity in providing improved lighting facilities in the home and workshop. Light, Mr. Ogley reminds us, is the most important tool placed at the disposal of the workman, for without light all other tools are useless. Self-interest might be trusted to induce manufacturers to avail themselves to the full of this tool that science places at their service, for poor illumination not only occasions actual loss, but is a constant menace to health for which no satisfactory excuse can be offered. This inducement is, however, insufficient, and it is to be regretted that practical illumination has not advanced as rapidly as improvements in the materials of illumination have made possible. A machinery of propaganda is necessary to drive home the need of desirable alterations in many workshops, and it is from this aspect that Mr. Ogley's book is so strongly to be commended. In the most straightforward way, he shows the object to be attained and how it may be accomplished.

At present, the instances of judicious and adequate lighting are mainly confined to new installations, and as a rule a comparison between the methods adopted in the older establishments and those of modern device is lamentably painful. Professor Marchant, who supplies a foreword to this book, quotes the case of a certain factory, where the average daylight illumination was 32 foot-candles, with a minimum of 8·6 foot-candles, whereas with flat flame gas burners (which are still in use to a surprising extent) the illumination was only 0·6 foot-candles. With such examples it is little wonder that the Home Office Committee on Lighting in Factories and Workshops should be impressed by the contrast between the depressing effect of dark surroundings and the cheerfulness of a brightly illuminated workroom, or that in the absence of legal enactments insisting on the provision of adequate light, they should urge the necessity for legal regulation. Surprise is rather occasioned by the fact, that the employer has not seen more clearly the direction of true economy, and made legal interference unnecessary. The author quotes the case of a munition factory, in which the output of a night shift was increased 30 per cent. by the introduction of an efficient system of lighting. Such a result, if it stood alone, might be traceable to indifferent lighting at the earlier date, but evidence shows that such instances are neither solitary nor exaggerated. Statistics derived from 209 factories in the United States, of which number 164 had of their own motion installed the latest

and most scientific appliances, show the beneficial results of well-distributed illumination. The quality of output is improved, the amount of waste from spoilage is decreased, the number of accidents to workpeople is diminished, and the loss of time is reduced. Saving in lighting is false economy, but where the returns from investment are not tangible and direct, it is difficult to persuade the works manager to embark on a policy involving considerable outlay. It is therefore desirable to repeat and to emphasise the carefully considered opinion of the Departmental Committee already mentioned, who deliberately assert that if properly-designed reflectors and modern lamps and burners were judiciously used, an economy of 10 per cent. in the lighting bills throughout the country could easily be made. A saving of hundreds of thousands of tons of coal could thus be effected, a consideration at any time, but a vital one surely at the moment.

The object of the author is to show that adequate industrial lighting, approximating to daylight illumination, can be secured under all the varied conditions in which mechanical operations are carried on, and to demonstrate the most appropriate means to meet particular cases. Attention is confined mainly to artificial lighting, but a chapter is devoted to daylight illumination that is worthy of consideration by reason of the elementary truths conveyed. The importance of provision for ample natural illumination is however very generally admitted, and architects have catered for workmen's needs very fully by adopting various excellent devices. The design of the saw-tooth roof, the provision of large glass areas, the construction of small bays and a plentiful use of northern sky-light have all contributed to abundant illumination with good diffusion, the absence of glare from polished surfaces, and the removal of other causes detrimental to good seeing. But in too many instances the employment of artificial light is attended by many drawbacks, the result of incapacity or indifference in original designing, but which admit of removal or remedy.

It might seem that the author is forcing an open door in insisting on the good results that follow an effective light installation. But experience does not support this view. A simple but great improvement at small cost was rendered possible by the introduction of the incandescent gas mantle, and the hopeful might have anticipated that the total disappearance of the flat flame burner was nigh. This antiquated relic still survives. To the thoughtful it seems only necessary—to ensure the replacement of the flaring "Batswing" by the more economical device—to state that the common flat flame burner cannot exceed 2 candle power to 3 candle power per cubic foot of gas of ordinary low-pressure quality, while the modern incandescent mantle in a well-designed lantern will give at less cost quite ten times the light. This and similar facts have long been known, but we are authoritatively assured that in one large manufacturing town nearly 50,000 flat-flame burners were still used a year or two ago. The judicious use of reflectors to shield the eye from glare and to concentrate the light in the most needed direction is as important as the production of an efficient light, and perhaps as little regarded. Many still need to be reminded that light in the wrong place is worse than wasted, for discomfort, if not actual injury to the eyes of the workers, is the consequence of neglecting the elementary rules of the art of illumination. There is still crying need for propaganda work, for informing the ignorant and awakening the indifferent. Mr. Ogley's clear statement, admirable suggestions, and pertinent comments, the outcome of large experience, deserve encouragement. We wish him success in his crusade.

In electric lighting similar opportunities for exercising economy occur, and as frequently remain unappreciated. The history of the progressive efficiency of the electric lamp shows that the improvements suggested by experimental science do not filter through into commercial practice with sufficient readiness. In spite of ample demonstration of easily effected economies, obsolete forms of lamp are still used. The gradual growth of the efficiency of the carbon lamps proves that finality is not to be expected. In the early days of these lamps, the consumption of energy was about 7 watts per candle-power, and successive modifications, as, for example, the "metallisation" of the carbon filament, have reduced this quantity to about 3 watts per candle. The long reign of the carbon filament, practically thirty years, has given it a pre-eminence that is undeserved, for a tungsten vacuum lamp operating with an efficiency of 1 watt per candle is four times as effective as the ordinary carbon lamp. It ought not to be difficult to convince intelligent management that the best lamp is not the one which sells at the lowest price, nor yet that which lasts the longest, "but is the lamp whose ultimate cost is the lowest, or with equal price and efficiency, the lamp which yields the longest useful life." Guided by this sound criterion the ½-watt lamp holds the pride of place at present. The comparatively long burning hours of the carbon lamp still cause it to be extensively used in the lighting of large working areas, but a careful comparison of the efficiencies of the ½-watt and of the enclosed arc lamp shows a saving of 50 per cent. in favour of the ½ watt, the improvement being more marked in the more powerful lights. Taking into account all charges, including interest and depreciation, the cost per candle-power hour in the enclosed arc lamp (energy, being rated at 3*d.* per unit) is 0·00463*d.*, in the 300 half-watt lamp 0·00313*d.*, and in the 500 watt half-watt lamp 0·00252*d.*

A serious competitor is the mercury vapour lamp, whose consumption is claimed to be as low as 0·33 watts per candle, but the details are not worked out so fully as in the case of the ½-watt lamp. Its use has become very general in the factories of the States during the last few years, where, as an industrial illuminant it has proved very effective. The peculiar colour of the light may be a disadvantage in some industries, but its rapidly growing favour declares its general availability. The lamp can be arranged for either a direct or an alternating-current circuit, and its advocates claim for it improved visual acuity, low intrinsic brilliancy, absence of glare and good natural diffusion. In addition, the average life of the tube is claimed to be as long as 4,000 hours and, since breakage of the tube destroys the electric circuit, fire risks are reduced to a minimum. These are characteristics which should ensure its ready adoption.

There must yet be considered the case in which neither gas nor electricity is available, and then recourse must be had to oil lighting. Fortunately, owing to improvements, the incandescent oil lamp competes not unfavourably with gas and electric equipment. Acetylene lighting is not considered in this work, and in remote districts where artificial lighting facilities are not existent, the incandescent oil lamp is regarded as the only fitting substitute. This is proved by the competitive tests to which gas and oil have been submitted. "A burner rated at 3 cub. ft. of gas per hour gave as the result of tests, a light of 12 candle-power. With an incandescent mantle and Bunsen burner 68 candle-power was secured with the same gas consumption, but with the same mantle, an incandescent oil lamp rated at half a pint of oil per hour actually yielded 600 candle-power." The incandescent oil lamp is equally suitable for inside and outside lighting, the effect is agreeable, and the illumination free from harsh glare. For emergency factory lighting, and in the case of additions and enlargement of premises where the labour involved in mains extension is undesirable and expensive, the system is without a rival. The upkeep is exceedingly small, 1 gallon of petroleum supplying a 1,000 candle-power lamp for 15 hours, and the life of a mantle is about 150 hours. At pre-war rates the total cost per 1,000 candle-power hours for oil and mantles was considerably below a penny.

Having chosen a suitable source of light, whether gas, electricity or oil, the grouping of the several units to give the most desirable arrangement is the work of the expert. The author's treatment of the wide subject of direct and indirect lighting, of local and general lighting, and of the methods of measuring the amount of illumination received on a particular area is informing and useful, but hardly sufficiently detailed for self use. It indicates clearly the results that can be achieved by a successful scheme, and should show how frequently inferior methods of illumination have been tolerated. The illustrations indicate a degree of perfection that may not be attainable in all cases, but suggest a high standard that should be our aim. Lighting, sufficient in quantity and equably distributed, is a valuable asset in a factory, bringing in its train good health and increased efficiency.

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PHYSICAL SOCIETY OF LONDON.

At the meeting held on October 25, at the Imperial College of Science, Professor C. H. Lees, F.R.S., president, in the chair, a discussion took place on "*The Case for the Ring Electron.*"

Dr. H. S. Allen discussed the arguments in favour of an electron in the form of a current circuit capable of producing magnetic effects. Then the electron, in addition to exerting electrostatic forces, behaves like a small magnet. The assumption of the ring electron removes many outstanding difficulties:—

1. There is no loss of energy by radiation as in the case of a classical electron circulating in an orbit.
2. Diamagnetic atoms must have a zero resultant magnetic moment. This is difficult to account for with electrons in orbital motion.
3. The ring electron gives a good explanation of the facts of paramagnetism, including the experimental results of K. T. Compton and Trousdale, and of A. H. Compton and O. Rognley, obtained by X-ray analysis.
4. The asymmetry of certain types of radiation can be accounted for (A. H. Compton).
5. The effect of the magnetisation of iron upon its absorption coefficient for X-rays observed by Forman is explained.
6. The small amount of ionisation of gases produced by X-rays may receive an explanation.
7. Grondahl claims to have found evidence for a magnetic electron in certain thermoelectric effects.
8. Webster has given a method of deducing Plank's radiation formula by making certain assumptions as to the internal mechanism of Parson's "magneton."
9. It is suggested that Bohr's theory as to origin of series lines in spectra may be restated so as to apply it to the ring electron. The essential points of the quantum theory and Bohr's equations may be retained, even if his atomic model be rejected.
10. If radiation is due to pulsations in a ring electron the Zeeman effect may be deduced by reasoning similar to that first employed by Lorentz.
11. The scattering of streams of electrons from the sun due to electrostatic forces would be to some extent diminished.
12. Parson has shown that many of the problems of chemical constitution and stereochemistry may be solved by a magneton theory of the structure of the atom. Stationary valence electrons are possible.
13. The forces of cohesion in a solid are similar in nature to chemical forces, both sets of forces having an electromagnetic origin.

The questions of the mass and magnetic moment of such a ring electron were discussed. It was pointed out that the adoption of this hypothesis would lead naturally to the acceptance of an atomic model with a magnetic core as previously suggested by the speaker.

Dr. D. Owen expressed regret at the unavoidable absence of Professor Nicholson. His contributions on the subject of atomic structure had already won an important place, and his participation in this discussion had been looked forward to with much interest. Dr. Allen had marshalled a number of lines of argument in favour of the conception of the ring electron. The evidence on the whole was scarcely convincing. Whilst from the point of view of certain phenomena a strong case might be made for its acceptance, it seemed equally true that in regard to other phenomena a strong case might be made against it.

The hypothesis of the ring electron was proposed by Parson in 1915, in a paper eminent for its lucidity of style, and for the fairness of treatment of prior views of the electron, and it related problems which arose in the investigation of atomic structure. The hypothesis met its most striking success on the side of its chemical application. It opened a wider range of interpretation of the chemical bond, explaining, for instance, not only the attraction of different atoms, as in a molecule of HCl, but also the attraction of atoms of the same kind, each electrically neutral, as in a molecule of hydrogen. The property of high stability of the group of eight ring electrons arranged in cubic order was decidedly interesting, and appeared to meet in a simple and satisfactory way the Law of Octaves apparent in the arrangement of the atoms in order of ascending atomic weight. Another feature was that places were reserved for six elements lying between hydrogen and helium. It was unfortunate that none of these places had yet been filled. The one immediately below helium, termed protofluorine,

might well have been expected to reveal itself in virtue of its possession of a unit valency. Parson, however, was only able to remark that its absence must be assigned to causes at present unknown. It would be premature to claim coronium and nebulium for any of these places.

Again, in reference to radiation, one of the chief advantages claimed for the ring electron was that it avoided the difficulty arising from the excessive rate of radiation of the atoms of the lightest elements on a particle-electron hypothesis. The ring electron would not radiate at all. But then the atom did radiate: How was the ring electron to permit of this? Not, apparently, without the aid of supplementary hypotheses tending to rob the hypothesis of its engaging simplicity. The conclusion might perhaps now be accepted as certain that there were circumstances in which the Newtonian mechanics did not hold (*vide* Jeans' Report on Radiation and the Quantum Theory, published by that society). This was a general consideration which might have application in solving the difficulties connected with radiation as treated by the ordinary electrodynamic theory.

Judged by its power of predicting new phenomena, the hypothesis of the ring electron was disappointing. Apart from the insertion of new elements of low atomic weight, the fresh phenomena which it pointed to were only of a secondary order, difficult to place in evidence and of little consequence if verified. In striking contrast was the fertility of Bohr's hypothesis of the atomicity of angular momentum, leading to the prediction of a hitherto unobserved spectral series, a prediction swiftly verified by the observations of Lyman.

Thus, on the whole, the ring electron could not yet be said to have shown its capacity of rising to the highly responsible duties imposed upon it by the varied atomic phenomena which it was called upon to explain and correlate.

Dr. W. Wilson said that the question of the energy loss by radiation was not really a difficulty in the case of the classical electron. We were obliged to keep to the quantum theory because it was impossible to deduce Planck's law without departing from the old dynamics, or rather, introducing special types of constraint. Now, on the quantum theory, the electron was capable of travelling in a stationary orbit for finite periods without radiating.

We might introduce ring electrons to account for paramagnetism with another group of electrons giving electrical conductivity.

Professor Nicholson's contention that co-planar rings of electrons were impossible was founded on the old dynamics; but it was unsound to apply the old criteria for stability. On the basis of the quantum theory he thought it might be possible to have co-planar rings.

He did not think it was possible to draw the conclusion that cohesive forces were electromagnetic from Michelson and Morley's experiment.

Professor Hale, of Mount Wilson Observatory, said he would take this opportunity of thanking the Physical Society of London for the Honorary Fellowship conferred on him some years ago. He would not venture to discuss the constitution of the electron but would refer to some solar phenomena which might be of interest in connection with it.

There were two classes of magnetic phenomena in the sun. In spots there were intense magnetic fields of 5,000 units or so extending over considerable areas, and there was no very clear explanation of the manner in which the necessary separation of charges occurred. If the separation were considerable one would expect some evidence from the Stark effect. A very careful search for this had been made but without results. With iron they had investigated the Stark effect in the laboratory and attempted to compare it with spot phenomena, and found that the electric field must be less than 200 units.

The general magnetic field of the sun was so small that the total displacement of spectrum lines was only about 1/1,000 A.U., i.e., the maximum intensity was about 50 units. Its polarity was the same as that of the earth, and the magnetic poles were 6½ deg. from the axis. The field diminished rapidly above the surface. It was undetectable at a height of 1,000 miles to 2,000 miles.

The president reminded the meeting of the observations of Rutherford and his pupils on the scattering of α-particles by matter. These observations led Rutherford to substitute the atom with a positive nucleus for the Kelvin-Thomson atom. As Dr. Allen had not mentioned the subject he would like to ask whether the ring electron would give the scattering found by experiment.

Dr. Allen, in reply, said that reference had been made to the mass of the positive part of the atom. It was not necessary to postulate a very small nucleus to account for the electromagnetic mass of the whole atom. The core might be complex and contain both electrons and α-particles; or the H atom itself might be built up of positive electrons, and it would be to those that we must attribute the small mass.

As regards scattering, Rutherford's deductions were inconclusive, as he had attended only to electrostatic forces. If magnetic fields were also considered it was possible to account for the scattering phenomena without assuming a very small nucleus. Then there was the question of where the Newtonian dynamics broke down. On Bohr's theory, this must occur somewhere between the electron and the core of the atom. If we adopted the ring electron in conjunction with a magnetic core, we might say that the Newtonian dynamics broke down within the electron. Personally, he did not accept Parson's theory as it stood; but although the ring electron was essential to Parson's theory, that theory with its distributed positive sphere was not essential to the ring electron.

SCIENCE IN RELATION TO THE INDUSTRIES OF THE SWANSEA DISTRICT.*

By Cosmo Johns, F.G.S., M.I.Mech.E.

Fuel, of suitable quality, is necessary for an expanding metallurgical industry, and as the output of iron and steel must always greatly exceed that of all other metals combined, coals for coking and for gas purposes are specially necessary. These particular types of coal are apparently lacking in the western portion of the South Wales coalfield, yet it is known that the coal seams exhibit a gradual transition from the purest anthracite to highly bituminous qualities. If the production of pig-iron and steel is to be increased to the extent foreshadowed as necessary for the economic stability of the country, immediate steps should be taken to investigate the coals of the district on scientific lines, and to determine which (if any) of the seams can alone, or as part of a mixture, be rendered available for metallurgical purposes. Concerted action by the coalowners and the iron and steel works of the district is called for. Experiments with different types of modern gas producers would cost but little if the outlay were spread over the industry, and could not fail to be remunerative if carried out under scientific supervision.

The Anthracite Problem.—That the vast anthracite deposits of the western part of the coalfield have not been favoured with the same appreciation as the Welsh steam coals is a constant subject of remark in the district, but apparently no concerted effort has been made to demonstrate its value. If the anthracite producers would but combine for the purpose of finding new markets for their output, establish a research and publicity organisation for the industry, and co-operate intelligently with any movement that promises a new outlet for their product! It has recently been stated by a well-known engineer with large experience that marine propulsion by means of gas engines is practicable on a commercial scale. This is a proposal that should have received eager recognition in the Swansea district.

Refractories.—The district has an abundant supply of high-quality silica rock for making silica bricks, but apparently there is a dearth of high-class fireclays, and no dolomite is being quarried in the district. As the fireclays of the Swansea district have never been investigated on scientific lines, it is probable that fireclays exist of quality equal to that of clays found in the eastern portion of the coalfield, and very likely have been passed through unrecognised many times during the sinking of shafts or driving of adits. The development of the spelter industry has been seriously retarded owing to the difficulties experienced in obtaining the necessary refractory materials, and in this industry alone the money lost would have paid for a complete survey of the district. That such a survey should be undertaken without delay is one of the most pressing needs of the district.

Iron and Steel Manufacture.—As a result of changes foreshadowed before the war, and hastened through the restrictions imposed by it, the district was called upon to change its methods, and from being a typical area for the production of acid open-hearth steel to become chiefly a producer of basic steel. This change, probably a permanent one, brings new problems for solution. The comparatively rich hematites being no longer available, recourse must be had to either the low-grade Jurassic ores which crop out along a broad belt from Oxfordshire to the north of Yorkshire, or to ores from overseas. When commerce resumes its normal trend, it is more likely that the Swansea district will look to the great French deposits near Caen for an almost inexhaustible supply of iron ore, richer in iron than the Jurassic ores of England, but rather high in silica. They were imported into Westphalia, so should be economically available for South Wales. With the largest iron ore reserves in any European country, France must be an exporter, and the Swansea district is the most favourably situated metallurgical district for smelting them. The basic open-hearth steel industry requires dolomite and pure limestone for its development. Limestone occurs in abundance, much of it of a high degree of purity, yet works are known to have used impure limestone, with consequent increase in manufacturing costs. Dolomite is an essential refractory material in the basic process, and it has yet to be proved that no suitable dolomite deposits are available in the district. The commissioning of a trained geologist to investigate the rocks of the Swansea area would not be a serious undertaking for the industry when once it has learned that science may solve many a problem that appears insoluble to the ill-instructed.

Tin Plate Manufacture.—The manufacture of tin plate is so firmly rooted in the district, and methods have become so standardised and workers so expert that increased efficiency would be difficult to achieve. It is just that industry, stabilised and standardised, which offers the most promising field for research and development. The cotton industry in this country has probably reached a state of technical efficiency equal to or even superior to any other in this country before the war, but the leaders of the industry have thought it desirable to form an association for research on broad lines. The formation of an analogous association by the tin-plate industry would be evidence of wisdom and prudence. The difficulty is not so much to suggest subjects for research as to decide between the most pressing. Electrolytic pickling has achieved great economy in acid and metal in some industries at a small cost for electric power. At least two systems of surface combustion are now available for low temperature heating furnaces, and one has long passed the experimental stage. By this means steel sheets could be heated to a rolling temperature with little oxidation and a reduced percentage of wasters. An investigation on a commercial scale would not be beyond the capacity of the trade. New uses for tin plate depend to a large extent on the resistance of the tinned surface to vegetable and other juices and solutions. Research on an extensive scale has been in progress in America for some time with a view to determining the conditions that favour the most protective coating with the lowest weight of tin per unit area covered. Here are three lines on which research could profitably be directed with the certainty that once started fresh problems would present themselves faster than the old ones were disposed of. The electrolytic deposition of thin iron sheets is technically possible, and costs have been mentioned that suggest its commercial possibility. The day is probably distant when melting furnaces and hot mills will become replaced by electrolytic tanks, but the possibility would not be overlooked by an industry that occasionally projects its vision into the future.

District Power Supply.—In each industry discussed, the trend is towards the use of electric power. The electrical transmission of power is the only method that meets the needs of modern industries. It is not too much to say that the progress of any metallurgical district will be conditioned by the rate at which electric power can be obtained. It has already been proved that cheap electric power is not confined to regions endowed with large waterfalls. The very effective organisation that controls the supply over the north-east of England is supplying power in bulk at a price per unit equal to that charged at Niagara. What has been done there is possible in the Swansea district, provided the whole district (as defined at the outset of the lecture) be organised and controlled, and every interest represented.

The Spirit of Scientific Research.—A striking example of the value of scientific research, when it is carried out by men of the requisite scientific attainments, exists in the district. An investigation which took the form of observing the influence of hot gases on certain alloys, and was an effort to solve a pressing industrial problem, gave disappointing results as far as the immediate object of research was concerned, but a new fact had been noted. It was only recognised to be new because those directing the research had been trained in pure science, and thus were accustomed to inform themselves—as a necessary qualification for undertaking research work—as to the state of knowledge in that particular subject. The new fact led to further research in a direction differing from that originally contemplated. Nickel carbonyl was discovered, and the great works at Clydach stands to-day as a monument to the value of scientific knowledge when applied to industrial problems. Unexpected discoveries have often been made in a similar way. But all this demands that those responsible for and directing the research should possess something of its spirit. It must be founded on a sound knowledge of pure science. The idea that it is only necessary to take a works analyst, call him a chemist, and ask him to solve complex industrial problems is still firmly rooted in the country. It is too often overlooked that those who are called upon to apply the principles of science to the problems of industry should at least possess a sound knowledge of those principles. In the domain of industrial research it is a truism that knowledge of the technology of the industry is of secondary importance to a sound training in pure science and proved ability to undertake research work. A tin-plate works manager, or even a committee of them, would almost certainly fail to elucidate the conditions that would favour the deposition of such a coating of tin on steel plate as would give the maximum of protection with the minimum expenditure of the more valuable metal. It would, however, be a most appropriate problem for a physical chemist of proved ability in research to undertake, even if he had never seen a tin-plate works. The most promising results in the investigation of refractory materials will be obtained when the work is entrusted to highly-trained scientific men who have escaped close contact with the worries of the manufacturer, and thus can bring a mind free from bias to the consideration of the problems that demand solution. The solution of the problem of removing dust and mist from the gases produced in chemical and metallurgical processes had baffled the leading chemical and metallurgical engineers, as well as their works chemists, until a professor of pure science applied the principles that govern high tension electric currents, took into account the recent advances in knowledge of the constitution of matter, and invented a method of precipitating dust and mist which is now being largely adopted. It may be added that Professor Cotterill devoted the profits of his invention to the encouragement and endowment of scientific research. It was a lady—Dr. Marie Stopes—who, as a result of her palæobotanical investigations, recently published a statement of facts and conclusions relating to the constitution of coal that must have a great influence on the research work now in progress in many centres with a view to elucidating the most suitable conditions for the scientific use of coal in industry.

Science and Technology.—When technical schools were established in all considerable towns it was thought that science and industry were effectively wedded, but the consequence was the retardation of the spread of real scientific knowledge. These schools did useful work in teaching the technology of several industries, and in giving some students the technology of several industries and also some students a knowledge of

* In our issue of November 8 we published a part of a lecture delivered by Mr. Cosmo Johns in connection with the meeting of the Refractory Materials Section of the Ceramic Society at Swansea. We now give the conclusion of the lecture, which was not available at the former time.

scientific principles when they could evade the pressure of local opinion which demanded "applied" science—which does not happen to be science at all. The spirit of the manufacturer who brought his son to a well-known professor of chemistry, and demanded that he should be taught soap manufacture and not science still lives in the land. The basis of all real progress in the technology of industrial processes must be a sound knowledge of the sciences whose principles are being applied.

The empire looks, and will continue to look, to this country, for its supply of highly-trained scientific workers and engineers. Mining, chemical metallurgical, electrical and mechanical engineers will be required for the re-shaping of the industrial world. Imperfectly developed countries like those of South America and the vast regions of Asia and Africa with only partly explored mineral wealth, must continue to look to the more highly organised industrial countries for leaders. These can only come from the United States, Germany, and Great Britain. The last-mentioned lacks facilities for training even the men that its home industries require. Therefore no university, college or improved technical college will serve the purpose intended. When university colleges were required, technical schools were built. It will hardly further progress now to erect university colleges when something of more importance is required. What industry, the country, and the Empire require are institutions of the highest type that can hold their own with those of Germany and the United States. Several universities in the provinces are making progress towards meeting that demand, but the type required is that of the Imperial College of Science and Technology in London, and the Swansea district if it really means to make an effective contribution to the requirements of the country, will insist that the standard of any degrees or diplomas given by the Institution it proposes to bring into being, and the general level of its teaching, shall at least be as high as that of the Royal School of Mines, which is a constituent college of the Imperial College. Though it will start without the wealth and prestige of the old school that has sent its students to the far corners of the earth, it can commence with the same high standard, capture something of its spirit, and will have one great advantage in being located in the focus of the most interesting and varied metallurgical district in Europe.

Professors of Mathematics, Physics, Chemistry, and Geology, should be elected before buildings are erected or technology thought of. They should be men old enough to have made their mark and proved their capacity for original work in the sciences they profess, while still young enough to retain the energy to build up out of nothing the Institution required. It is fortunate that pure science demands no vast equipment, and even in technology it is not institutions with the most elaborate equipment that have made the most original contributions to knowledge. When, and only when, pure science has been amply provided for, need thought be taken for the teaching of technology.

The Work of the Proposed Institution.—It is to provide for the training and inspiration of the men, and if needs be the women, who seek to occupy positions of responsibility in the metallurgical and related industries, not merely of the district immediately served, but of the British Empire. Success will have been achieved when those who have been trained within its walls have given proof when faced with industrial problems, and commercial responsibility, that they possess not only the necessary knowledge of science and technology but enjoy a reputation for a standard of professional conduct at least equal to that of the old students of the Royal School of Mines, London. To perform its functions fully, the new Institution ought to provide for the training of mining engineers (metalliferous), metallurgical engineers, mechanical engineers, electrical engineers, chemical engineers, the first three at least to be provided for at an early stage. Facilities should also be provided for training research workers, and thus to produce a type of scientific worker to whom the nation and the Empire can look for the solution of problems that industrial progress and international rivalry will present continually. This would not be the standard of a mere university college. The institution should at least be autonomous, loosely associated with the university at first if no escape be open, but determined, sooner rather than later, to stand by itself when its ideals had been realised, and to co-operate by exchange of students with other Institutions within the Empire of equal standing. As its growth and development would be a national gain, and the realisation of its ideals would constitute a bond with the Dominions beyond the seas, its upkeep should not be the sole or even a considerable charge on the local community, but Government might be expected to contribute approximately the money that Germany thought necessary to pay yearly to many centres of learning

Economic Science and Industry.—The laws of economic science are not so well established as those of other sciences because industry has failed to recognise that its activities are governed by any scientific law, and opportunities have been rare for the study of special problems in a great industrial area. The study of the economic changes of a well-defined industrial area, together with earnest teaching, might well have the effect of eliminating causes of industrial quarrels.

THE UNIVERSITY OF BRISTOL.—A report just issued shows that the number of day students on the registers during the past season was 102. Of these, 76 were serving either in the army or the navy. Arrangements have been made by which those who have served through the war may be excused one year of study, and the intermediate examination for the degree of B.Sc. in Engineering.

THE LABOUR ISSUE.*

By ALEX. RAMSAY.

THE most urgent task we have recently had to face was to settle our differences with that European Power which placed itself above the law and threw the gauntlet of might in the face of civilisation. The next urgent, important, and probably more difficult task is to settle the differences amongst ourselves. In the former we were dealing with an evil we came to understand, and serious though it was, it yielded to the terrible but effective remedies that were applied. In the latter we have something more deep-seated and menacing, because the conditions which give rise to unrest in industry are as yet very incompletely understood, no really serious attempt has yet been made to investigate them, and the result of prolonged industrial strife would be completely disastrous to our national future. What a spectacle we should provide for history if we saved humanity by a stupendous array of united force and afterwards destroyed the foundations of our own strength by refusing to embrace progress with justice, or by turning away—because of selfish interest—from any basis of agreement that will save us from the irrecoverable losses due to lack of industrial unity. And when we speak of unity we do not simply refer to freedom from the strike or lock-out. These are bad enough, but they are not nearly so disastrous to our economic welfare as the difference of ideal which causes or permits the almost universal failure to make the most of our manufacturing facilities.

In time of war the duty of the corporation or individual engaged upon the production of the weapons of national defence was so perfectly clear that we did not hesitate to stigmatise in the strongest terms the conduct of those who fell short of our patriotic standard. But what is not so fully realised is the fact that we are engaged upon an economic war every day of our normal lives, and that unless in this field, too, we discover some means of unifying our aims and our efforts, the degradation of our country's status will follow, perhaps not so rapidly, but as surely and effectively as if we had been crushed by military force.

Now I should like to postulate some truths upon which I think we shall be agreed and afterwards to consider their importance more in detail. In the first place it should be recognised that as a manufacturing nation our material well-being is greatly influenced by the facility with which we can exchange those things we produce for the commodities we desire and must obtain from other peoples. That exchange we describe as our foreign trade. The greater the volume of that trade, the greater the amount of employment in this country. The more we export the more we are able to import for the comfort of our people or the increasement of our national capital. But it is also true that we have no monopoly of foreign markets. There is no Divine dispensation that British goods must be accepted in preference to those of other nations. The determining factors are usually price and quality, and these are largely under the control of the employer and employed.

In the second place it must be seen that under our existing wage labour system the co-operation of Capital and Labour is essential to production. They are necessary to each other. Without the one the functions of the other cannot be exercised, and reducing the matter to its elements it is quite evident that if the two do not work harmoniously and efficiently together, if they fail to make the most of their power to produce, the cost of production will be unnecessarily increased, the ultimate welfare of the country must inevitably be to that extent prejudiced. You have two curves; as industrial inefficiency moves upward reaching the ascendent, other things being equal, prosperity falls away and the nation suffers.

As this is true, the third thing to be noticed is the more incomprehensible. Industrially speaking, the British Nation, Limited, is a producing concern with two partners, the employer and the employed. The success of the business should naturally be a vital matter to both because it is the source of their income, but as a matter of fact we find at a generous estimate that the business does not produce more than 60 per cent. of its possible output, that the prices of its products are much higher than they need be, and in consequence there is scarcely a market in the world in which they have been accustomed to deal where they are not now losing trade to more industrious and efficient rivals. The reasons are several, but not the least lies in the fact that the partners do not pull together. Each is playing his own hand. The worker has the conviction burned into his very soul that he has been unfairly treated in the distribution of profits, and so the dominating idea of his mind is not the need for production but the necessity of making the employer disgorge. The employer, on the other hand, is keenly interested in the welfare of the business, but he observes the unsympathetic and somewhat belligerent attitude of his associate, and in too many instances comes to the conclusion that his only course is to hold to what he has until forced by overwhelming circumstances to yield. And so the sorry play proceeds until the climax of ineptitude is reached when they start fighting one another and substitute destruction for disintegration.

Now the employers are perfectly aware that in this position they are confronted with an issue of the utmost seriousness, and without any doubt there is the will amongst them to find an equitable solution if such be possible. They realise clearly enough that if they have to fight their workers they have nothing left with which to fight their competitors, and if their initiative in the direction of industrial reform is not as yet very pronounced we shall find one explanation if we try to understand the conditions which shape their point of view. There is a disposition amongst a section of the workers to regard them as their natural enemies, as those who deliberately and with studied and selfish intention look upon their men as profit earners only, whose every social ambition should be crushed if possible, lest it take something out of the pockets of Capital. I do not admit for a moment that such is now a true description of their attitude. If consciously adopted it would be utterly immoral and a crime against humanity. But the average employer individually is just as moral and just as humane as those who work for him, and we shall get a much fairer indication of the working of his mind if we consider some of the circumstances with which he is faced in the daily conduct of his business. To put the matter briefly, unless he produces the maximum possible at the cheapest price he is in danger from his competitors, and unless his workers help him in these endeavours there can never be a cordial sympathy between them. What is the position?

It is difficult after four years of the abnormal conditions due to war to arrive at a satisfactory conclusion about Labour's attitude, because there is no doubt that special circumstances such as indispensability, long hours, high prices, nervous stress due to family losses, the abrogation of trades union privileges and so on, have created a combination of conditions which are hardly likely to be repeated. But at the same time, the experiences of Labour during this period must have a considerable influence in moulding its outlook on post-war and normal problems, and that outlook as it exists I do not regard as a healthy one. What are the tendencies most to be feared? The first is the impotence of the officially appointed and recognised trades union leader. Time was when he was an ambassador who had power to negotiate a treaty that would be kept. He is now a delegate who carries out, whether he approves or not, the mandates of the rank and file. Time and again, in all parts of the country, we have had stoppages of work against the advice and instructions of the trades union executives. Many of them have been quite unreasonable expressions of the personal feelings of the more dominant spirits, who have overthrown all the obligations of their societies with a truly Prussian contempt for anything but the will to achieve their own desires. Not so long ago there was a stoppage in the Midlands which threatened to spread and become a first-class national disaster. After about a week of idleness the strike committee in a large city called a meeting to hear a statement and to consider whether work should be resumed. About 15,000 workers crowded into a huge market building, and the question was put. A sea of hands in favour and presently a sea of hands against. Counting was impossible. Those in favour of resumption were then told to move to the right of the building, those against to the left. A wonderful sight to see that dense crowd adjust itself and evolve order out of chaos! But again the forces were so equally divided that no one could tell whether the answer was "Yea" or "Nay." The strike leaders stood together on the platform, whispering and wondering what to do next, when suddenly one stepped to the front and shouted "Get back to work, the lot of you," and back they went! A magnificent example of crowd psychology; a pitiful spectacle of the hazard in which grave national interests may be placed if impulse is to rule a body which aims at becoming a dominant party in the State. I am absolutely convinced that there is no hope for a better and permanent adjustment of economic relations until the workers return and rigidly adhere to the constitutional method, and I see the utmost danger to the community and its industrial welfare if they do not. Not only so, but trades unionism ceases to have a meaning if it depart from its basic principle of unity of idea, unity of purpose, and unity of execution, and these can never be attained until the leader has been reinstated and reclothed with authority.

The second tendency to be deprecated and one closely akin to the first, is the present activity of the rank and file in what is known as the shop-steward movement. Now let it be clearly understood that there is no objection to the shop steward. He has a well-defined place in workshop economy. I have dealt with shop stewards for a good many years and would prefer to negotiate with them than with the individual workmen. The shop steward is the representative in a department or factory of the executive authority of his unions. But he is not the authority, and it is because in many cases he has usurped the function and abused it, that the employers are not anxious to encourage the development of his influence. I heard of a case in Glasgow the other day where two shop stewards approached a head foreman and told him that at a certain time that day he would have to finish. And he had to go! In normal times such a demand, if pursued, would, of course, have closed these works and probably a good many others. My object in referring to it is not to have a tilt at Labour, but for a much deeper reason. There is a strong and growing demand in trades union circles, supported by the Committee on Reconstruction, that the worker should be given a much larger voice in workshop control. Such a result is very desirable and very necessary, and would mark a definite step forward, but here again it is quite certain that the employer will bitterly resist every encroachment on his authority until it can be shown that the men have cultivated a sound sense of responsibility and do not seek to place him at the mercy of the uncertain whims of minor trades union officials. Every day of his working life he is striving to achieve a scientific combination of the forces of production. When you present him with the disrupting conditions arising from "every shop steward his own executive" you invite at once and with reason, his most determined antagonism and resistance.

Now it may be that these two conditions are evil

*A propaganda address delivered to a gathering of employers and workers at Motherwell on November 14, 1918.

products of the evil times through which we have lived, temporary phases which will disappear in the larger atmosphere we hope presently to reach. But even then before community of interest can be attained the whole attitude of Labour to the problems of manufacture will have to be radically changed, and it may be added as a necessary corollary that the attitude of the employer in relation to the distribution of the profits of production will have to be considerably changed, too. But dealing with one thing at a time, let us recognise the fact that the worker frankly does not believe that his interests and those of the employer march hand in hand. And why is it so? Because time was when the employers were not over scrupulous about the conditions under which their servants worked nor the methods adopted to inflict their will upon them. Accidents without compensation, sickness without pay, unemployment and hunger, have written many a grim page on the history of the working classes. They have achieved recognition of their economic importance in spite of the passive and sometimes organised resistance of the ruling and employing classes. It is no matter for surprise that with the inherited instincts of oppressed forbears, with the subconscious mind peopled with the ghosts of generations who have laboured and suffered, the expression of their power should be antagonistic to those who have ruled and prospered under the old *régime*. But just as charity is twice blessed—to those who give and those who receive—so is revenge twice cursed—to those who inflict it and those who suffer from it.

As a general statement, the result is beyond question, that if Labour wittingly or unwittingly in this generation destroys the employer, it destroys its own economic security at the same time. And that is the tendency! Industry can stand higher wages, it can stand shorter working hours, it can stand, in brief, an immense improvement in the workers' status, but it cannot carry these additional charges, if they are to be accompanied by a complete indifference to the volume of production, by lost time, by resistance to labour saving appliances, by the limitation of output. At present there is a tremendous emphasis upon the former and an almost complete silence about the latter. I do not propose to dwell upon these evils because I am anxious to avoid anything in the nature of unnecessary criticisms, but if Labour wishes to do itself the greatest service, and at the same time render to the community one of inestimable benefit, it will consider its duties as well as its privileges and in a statesmanlike fashion worthy of its aims and its powers will address itself to a remedy which must be found, before its ambitions can safely be realised.

Limitation of output alone has operated disastrously against the prosperity of British industry. I do not blame the workers for its existence. In many instances it was the only possible reply to the rapacious methods of the employer. When they let themselves "all out" the fruits of increased effort were often seized, and they found that the top speed did not pay any better than the moderate. And so they did the obvious thing which was to put a brake upon their energies. But we have now arrived at a stage when they are powerful enough to protect themselves *constructively* against unfair advantage. That is to say, they can ensure payment for all that they produce, and there is no further justification for withholding production on the ground that only the employer will reap a direct advantage from maximum output. If we assume that the British worker is 75 per cent. labour-efficient and the American is 95 per cent., the loss to the industry of this country is not represented by the 20 per cent. difference, but is something very much greater. Both are attempting to sell their product in the same neutral market, and that 20 per cent. is a preferential tariff in favour of our competitor. It is much more than sufficient in many cases to give him the business and it is through the operation of this circumstance that our most serious losses arise. The worker is justified in demanding from industry the greatest benefit he can obtain. He is justified in asking much more than he has ever received. He can without a doubt enormously improve his social status without injury to any vital interest of the nation, but he can only do it if he change his philosophy and agree to give in order that he may receive.

The duties then which Labour owes to the country and which must be insisted on at every turn and enforced by every legitimate means, are "responsible judgment by qualified authorities instead of hasty decision by irresponsible groups," "constitutional procedure" and "maximum effort." And what of the employer? We have demanded certain conditions from Labour which neither the employer, the Government, nor the public can enforce. They can only be realised if the workers admit and give effect to their moral obligation to the community. But if the worker has a moral duty it would be illogical to deny that the employer, too, has one, a duty which is incompatible with the old idea that labour is a commodity to be purchased as cheaply as possible, a piece of mechanism to be operated, to be exhausted, and thrown aside when something more efficient is available. If the worker fulfil his part of the contract he is entitled to expect from industry a fair share of the profits of production. He is entitled to expect a recompense that will make it possible for him to develop to the fullest his mental, moral and physical faculties. He has a claim on the joy of life. He should taste of the humanities, and he and his dependents be no longer subject for the necessities of life to the exigencies of health, accident and unavoidable unemployment. Treat him not as a producing but as a social unit. Moral considerations certainly, but I have an immense assurance in the powerful influence of moral forces. If the world had been unable to rise above mere material considerations in August, 1914, and since then, civilisation might even now have been crawling in the dust. But we had a spirit of honour, truth and loyalty, which has made this nation a steadfast and heroic figure in the eyes of the world, and it is something of that spirit which we must catch and transmute into our industrial life. I do not believe the employers will stand in the way. They are not actuated by greed and selfishness nearly so much as by fear; fear that the fabric which they have built up and which represents their material existence will be unable to bear the strain that Labour is trying to put upon it. But if we progress sanely, constructively, co-operatively; if we eliminate the vendetta; if democracy does not shut its eyes and project itself with ruthless, undirected force, there is nothing in the problem of equitable readjustment which offers any vital difficulty to a solution. Where you have a scientific basis for agreement reinforced by moral sanction, we should indeed be bankrupt of honesty and statesmanship if we failed to evolve that league of interests which the safety and prosperity of the nation demands.

The paramount duty of the employers at this juncture is not only to welcome, but to seek every reasonable means by which a better understanding can be attained and sound progress assured. I do not wish to enter into a discussion of their domestic duties, but it is difficult to avoid doing so in view of the fact that their outlook, knowledge and attitude to Labour, have a powerful effect upon industrial relations. There has been a disposition amongst them to regard the labour problem as an unavoidable affliction, and to leave it there. It is nothing of the kind. It is an intensely human problem, the solution of which is in the hands of the personal elements which dominate it. Too much stress cannot be laid upon this point. If we examine the history of more than one industrial dispute in recent years, disputes which have had disturbing and dangerous possibilities, we shall find that perhaps not the direct cause of trouble, but certainly the failure to avoid it, has lain, not in a fundamental difference at all, but in the personal characteristics of the leaders on one side or the other. An endeavour should be made to obviate this on the employers' side by developing a uniform policy and unity of control. The average employer is an extremely busy man, who is able to give to his labour conditions only superficial attention, whereas they need nothing less than analytical and scientific study. There is no doubt that if the employers' federations maintained reliable commissioners in defined areas, to examine local conditions, and acting with the executive, to co-ordinate policies, advise members, and assist in negotiations, an immense number of difficulties which now lead to friction and dispute would be avoided or overcome.

It seems clear, too, that if the personal factor is an important one, the employers should do something to establish or accept some machinery for getting into closer touch with their workpeople. Contact is a great destroyer of illusions! In the march of events they will have at least three things to face, the maintenance or increase of the present standard of wages, the shortening of working hours, and the attempt of the workers to achieve self-determination of other working conditions. If they believe that the granting of these would be prejudicial to industry unless accompanied by certain safeguards such as increased production, it is obvious that they should take every opportunity of representing to the workers the safeguards they have in mind and the necessity for them. The various local, district and national councils recommended by the Whitley Commission provide a suitable means. They should be developed gradually because the worker has to be educated to the necessity of coming with constructive aims and not simply to barter for further privileges—but they should be developed. We may as well face the fact that the day of domination by the employer is nearly over, and we are called upon to decide whether it is to be replaced by a constant struggle between equal forces, or a working alliance between those whose interests are fundamentally the same. If, as I trust, the latter, the sooner and the closer we get together, the better it will be.

The next consideration of importance and one more of principle than of machinery, is the necessity of ensuring that the interests of Capital and Labour are not only theoretically the same but extend from the production to the distribution of wealth. The problem should be approached with a fixed idea that a substantial improvement must be made in the state of Labour, and there will be no difficulty in getting the employers to take this view if the workers accept the conditions I attempted to lay down, and by sober action and more efficient service do something to meet the extra charges on industry. It is perfectly clear that Labour is growing so strong that the employer will sooner or later have to face the issue that the workers bargaining on level terms will present a demand for a definite share of the profits of production and something will have to be done to meet that demand or we shall be face to face with the biggest internal crisis this country has known. Make no mistake: a stoppage of work organised by a general Federation of Trades Unions such as we shall presently have, opposed by a general federation of employers, would in a few hours resolve itself into civil war, and that would be too expensive a price to pay for lack of a little foresight.

There are two possible ways of meeting the situation. It is even now commonly reported in certain circles that when the present excess profits tax is removed it is the intention of the Government to levy a tax of 10 per cent. on the profits of all industrial concerns. The gradation of such a tax is one way. The other is to more or less definitely limit the amount of dividend which may be paid on invested capital, making the arrangement elastic enough to ensure that a point is never reached when there is no advantage in producing more, because if such a limit were artificially fixed it would operate with deadly effect against our industrial enterprise. I cannot enter into a detailed examination of these proposals, but there is every probability that they will one day have to be considered.

As a concluding thought let me say that out of the maelstrom of conflicting ideals, opinion, programmes, passions which surround the labour issue, there is one truth beginning to stand out with perfect clearness, that the industrial problem is a social, moral and educational problem, too. They cannot be dissociated. The qualities of heart and mind which make a man a decent, upright and thinking citizen, are the qualities which are most to be desired in the workers of the country, and they can be largely influenced by circumstances within our own control. During the past four years this nation has faced the biggest crisis in its history. It has been fighting for its life. On the whole it has been worthy of its traditions, its opportunities, its power. But we have been searched through and through and our weak places laid bare. What have we found? That our physical and moral stamina was impaired, our efficiency reduced, through the existence of certain crimes against society which political factions have quarrelled over for a generation and done nothing to remove. We are at last committed to a solution of the housing, drinking and educational problems, and if the workers and the employers would now unite their forces to see the solution applied they would at the same time be adopting the finest expedient for effecting and maintaining the industrial peace. Here, again, the district and national councils provide a channel of action and apart from any other result, incalculable benefit would arise from the understanding and sympathy engendered by the fact that they were fighting a common enemy instead of one another.

But who will deny the potency of a man's domestic environment on his health and mental outlook? The workers have a tremendous responsibility because they hold largely in their hands for good or ill the economic prosperity of the country. When we appeal for the strenuous effort and willing co-operation of a man who is housed in a dirty, squalid and noisy dwelling, where it is difficult to maintain the decencies of life, apart from its comforts, he may not unreasonably take the view that industry owes more to him than he owes to industry, and regulate his action accordingly, and as a matter of fact he does. No one will now hold that the drink traffic should be allowed at will to demoralise and corrupt the community, or that restrictions which are necessary for the production of munitions are less desirable when we are engaged upon our peace-time pursuits; and no one will deny that a better educated democracy would be one to which we could look with greater surety for a sane and balanced use of the political and economic weapons they possess. The employer above all men should weigh these considerations and exercise an enlightened public spirit, in keeping with the interests he has at stake and his powerful influence on society.

I wonder if you have ever sat at the side of a highland loch, in the perfect silence of the twilight, and the everlasting hills about you—sat—and examined into yourself, to find what kind of a man you were? This people unconsciously has been going through that process of introspection, and if we do not emerge from the experience with a higher idealism, a clearer vision, a wider outlook, if we do not get a nobler conception of the value of humanity and the right of ordinary mankind to enjoy the fruits and beauties of the world, then this welter of blood and sorrow will have been in vain. We must no longer allow selfishness to override justice, or personal interest to come before the common good. Workers and employers alike—for it applies to both—must embrace a new philosophy, that our industrial pursuits are not only a battle ground for personal aggrandisement, yielding plunder to the stronger side, but are to be regarded as a common trust administered by both, through which the prosperity of the whole community should be assured.

Worker—or employer—has a duty to his country as well as to himself, and he who will not face this duty must have it forced upon him. If our antagonisms are to become intensified, each side fighting for its own hand, reckless of the fact that war ultimately brings dissolution, then indeed we may despair. But if we have not genius we have a saving commonsense, and on that good sense we must rely to steer for us a middle course between reaction on the one side and illjudged experiment on the other. My hope is high! I cannot believe that we shall unite in adversity to destroy each other when the outside danger is past. Men of sober judgment and unselfish aims, men who love truth and hate oppression, who are not swayed by passion or frightened by vested interest, in whose keeping the conscience of the community will be safe—in the ranks of both employers and workers you will find them—these are they who alone can guide us through the difficult times that lie ahead, and lead the new democracy to a State where "New Arts shall bloom of loftier mould," where truth shall prevail, and where "Justice shall reign throughout its halls."

INDUSTRIAL RECONSTRUCTION.—Mr. Kellaway, M.P., Parliamentary and Financial Secretary of the Ministry of Munitions, will address the Industrial Reconstruction Council on "Developments in British Industry During the War," in the Conference Room, Hotel Metropole, at 3 o'clock on Friday, the 29th inst. (to-day). Sir Wilfred Stokes, K.B.E., will take the chair.—A conference on the Functions of Industrial Councils will be held under the auspices of the Industrial Reconstruction Council on Tuesday, December 3, at 6 p.m., in the Hall of the Institute of Journalists, 2 and 4, Tudor-street, E.C. 4. The subject will be introduced by Mr. E. McGegan, of the Ministry of Labour; afterwards the discussion will be open. No tickets are necessary.

THE WEAR OF METALS.

In the course of a paper under the above title which he read at the autumn meeting of the Iron and Steel Institute, held in New York in 1890, at a time when the tensile test was practically the only test followed for ascertaining the suitability of all grades of steel for every purpose, the late Dr. C. B. Dudley assumed that at least three elements entered into the problem of wear, and his first assumption was to the effect that the metal which will suffer the most distortion without rupture will wear best. This first variable being obtained in satisfactory amount, an increase in tensile strength will add to the wearing power of the metal. In the third place, Dr. Dudley assumed that of two metals which have the same tensile strength and the same elongation, the one which is the finer in granular structure will wear the slower. The late Sir Lowthian Bell, speaking upon this paper, gave a few examples of the behaviour of rails and tyres in service on the North-Eastern Railway, and stated that fracture in rails was due to occurrences entirely dissociated from the chemical composition of the metal; the rails had been cooled either too suddenly or too slowly.

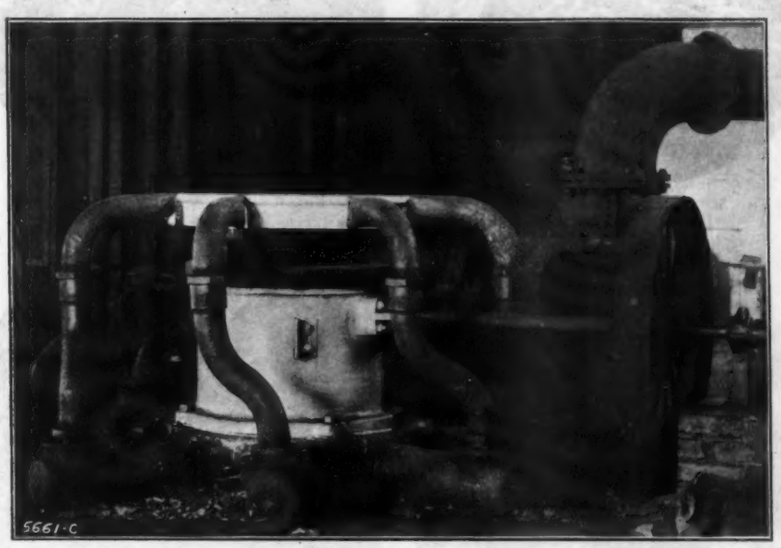


Fig. 3. Plant for Treating Tyres.

At all events, he added, he had not been able to trace a fracture to any chemical cause.

Since these comparatively early days in the metallurgy of carbon steel, an immense mass of data has been rendered available on the subject, and metallography has become a practical science; methods of testing have been improved and have been developed so as to cover actual service conditions; and the constituents of steel, together with the critical ranges of temperature, have been discovered, these latter enabling the correct heat treatment of steel to be effected and also the obtaining of different textures of the metal in one and the same piece. If Dr. Dudley had contributed the paper above referred to a few years later, he might have used the term "Sorbite" to determine the finer granular structure he alluded to. According to the late Mr. F. Robin, the granules of sorbite can be so fine that it is very difficult to distinguish them even when the enlargement is a thousand diameters, this being the scale usually worked to for that texture. Dealing more particularly with rails, Mr. Osmond stated, in 1895—in "Microscopic Analysis of Metals." by F. Osmond and J. E. Stead—that in his opinion the present method of manufacture of rails, &c., would probably appear primitive in later years; he hoped that the greater quantity of pearlite in our steel would be replaced in future practice by sorbite.

The progress in steel manufacture and treatment very briefly outlined above has made those whose vocation it is to examine steel in all its aspects realise that the fields for improvement give scope for inexhaustible study. The true steel expert freely admits even now that he knows very little concerning steel; he still confines himself to assumptions. Scientific study is as essential as it has ever been, but it must of necessity go hand in hand with the commercial aspect if practical results are to be achieved. While the steel users, the railway companies in the particular case with which we are now dealing, are demanding material of a higher quality, prevailing conditions preclude any radical modifications in present methods of manufacture. An ideal improvement in the manufacture of rails and other rolled steel products would therefore be the one to be carried out, whilst complying with the four following points: The improvement not to reduce the existing output of rail mills. No scrapping of existing plant or erection of elaborate new plant to be required. The improvement not to increase unduly the cost of the finished rails and other rolled material. The improvement to increase both the safety and the durability of the articles manufactured.

A process for hardening steel rails and tyres by compressed air, recently invented and patented by Messrs. Sandberg, the well-known consulting engineers, has been found to meet these conditions and deserves serious consideration. Messrs. Sandberg, in the course of their long career, have had opportunity of studying steel from the point of view of both manufacturers and users, and we may recall a paper read before the Iron and Steel Institute at the autumn meeting, held in Stockholm in 1898, by the late Mr. C. P. Sandberg on "The Danger of Using Too Hard Steel Rails,"* a paper which probably did much to safeguard railways from using excessively hard steel rails without due consideration for safety. But at that time (in fact, hitherto) rails were generally laid in the track as rolled, when their composition was found to meet a given chemical analysis, and after undergoing specified drop tests. Attempts had been made at different times previously, both in this country and in the United States, to find a method of tempering rails which could be adopted economically, but the measures followed involved the quenching of the rail from a high temperature and then the reheating to arrive at a given temper, processes not only slow and very expensive in their operation, but which were also difficult to control and gave uncertain results.

Messrs. Sandberg realised that the right temper in the rail could be obtained in the course of one single operation if the correct rate of cooling through the critical range of temperature were secured. Their experiments, using air cooling, were so encouraging that they were soon able to treat full-length rails of heavy section, the results they obtained making it perfectly clear also that their process could be carried out without interfering in any way with the output of the rail mill and at a comparatively low expenditure. The first rails treated were tramway rails, and gaugings taken from these after they had been one year in the track, under very severe traffic, showed that their life would be about 100 per cent. longer than that of Sandberg high silicon rails of the same composition, but untreated, and laid at the same time in the same track.

A plant for the Sandberg treatment of rails has been put down by the Bethlehem Steel Company, at their Sparrow's Point Works, where trials have been carried out and excellent results obtained. This plant is illustrated in Fig. 1, on page 616.

Shortly after the experiments had proved the value of the process a suitable plant for treating rails was put down at the Dowlais works of Messrs. Guest, Keen and Nettlefolds, where a number of trial orders have been carried out on rails for various home railways. The plant is illustrated in the view, Fig. 2, page 616. It is located at the delivery side of the rail mill and consists, as will be seen, of a series of air pipes connected to a compressed air receiver. The rail coming from the hot saw, at a temperature of about 900 deg. C., is brought under the horizontal air delivery pipe; in this latter a series of ports are cut, from which the compressed air escapes on the railhead. The compressed air is delivered on the railhead at a pressure of about 15 lb. per square inch.

The plant for the "air-toughening" of tyres is shown in Fig. 3, annexed; it works on the same principle as the rail "air-toughening" plant. The tyre is revolved slowly during the process, and the air delivery pipes are so jointed that tyres of any size can be treated.

A series of tests was carried out in February last by the National Physical Laboratory on a 95-lb. B.S.S. bull-head rail, made for the Metropolitan Railway by Messrs. Guest, Keen and Nettlefolds. The rail, 45 ft. in length, was cut in half, one half was left as rolled and the other was treated by the Sandberg sorbitic process. The tests given below were carried out on two pieces, one from each half, the untreated portion being marked 14–42 and the treated portion 14–42.*

1. *Abrasion Test* (*Sliding Abrasion*).—The test pieces were machined from the heads of the rails (as shown in Fig. 4). For the purpose of this test the specimens were machined to 1·000 in. in diameter and 8 in. long, and were fixed in a chuck revolving at 2,000 r.p.m.

Fig. 4.

The outer end of the specimen supported a hardened steel ring 1·116 in. diameter loaded with a weight of 410 lb., and rotating at the same speed as the specimen, so that the slip per revolution was approximately 0·36 in. After running for 20 minutes (40,000 revolutions), the wear was measured by a micrometer. At least two tests were made on each specimen, and the results are given in Table I, the wear being expressed as thickness of surface layer worn away in mils per 1,000 ft. slip, and the relative resistance to sliding abrasion as the reciprocal of this number multiplied by a hundred.

2. *Abrasion* (*Rolling Abrasion*) (*Saniter Test*).—For this test the specimens (1·000 in. diameter) were fixed in a chuck revolving at 2,000 r.p.m. The outer end carried a hardened steel ring 1·5 in. diameter fixed in a ball bearing to which was attached a dead load of 410 lb. Wear took place due to the rolling of the steel ring on the surface of the specimen and was taken as the reduction in diameter in ten-thousandths of an inch after 200,000 revolutions of the specimen. The relative resistance to rolling abrasion was taken as the reciprocal of this value multiplied by 1,000. The results are also given in Table I.

(3) *Brinell Hardness*.—A flat ¼-in. square was made on the centre of each test bar and a Brinell ball impression made on this flat using a ball 10 mm. diameter and a

TABLE I.—Results of Sliding and Rolling Abrasion Tests and of Brinell Tests.

NP Eng. Dept. Test Mark.	Identification Marks on Rail.	Sliding Abrasion.		Rolling Abrasion.		Brinell Hardness Number.
		Thickness Removed in Mils per 1,000 Ft. Slip.	Resistance to Sliding Abrasion.	Wear in Ten-thousandths.	Resistance to Rolling Abrasion.	
HH1A (ordinary)	14·42	1·35† & 0·87	74 109	5	200	225
HH2A (sorbitic)	14·42*	0·32	310	3½	290	268

† The value for the two ends of the bar were slightly different. Each figure represents the mean of two tests.

* See Engineering, vol. lxvi, pages 304 and 308.

load of 3,000 kg. The load was applied for 60 seconds and the diameter of the impression obtained by a measuring microscope. The hardness numbers were calculated from the following formula :—

$$H = \frac{W}{A}$$ where H = Brinell hardness number.

W = Load in kilogrammes = 3,000.
A = Spherical area of indentation in square millimetres.

4. *Notched Bar Impact Tests.*—

Condition of Test.	
Temperature	20 deg. Cent.
Weight of striking hammer	10·35 kg.
Striking energy	5·3 kg.m.
Dimensions of test piece, exterior	10 × 10 mm.
Dimensions of test piece at bottom of notch ...	10 × 5 mm.
Length of test piece ...	53–1/3
Span	40 mm.
Form of notch	2/3 mm. radius, round

TABLE II.—*Results of Notched Bar Impact Tests.*

NP. Eng. Dept. Test Mark.	Marks on Rail.	Energy Absorbed in Fracture.		
		Kilog. Metres	Kg.M./Sq.Cm.	
HH1B	14·42	0·22	0·21	0·42
HH1C (ordinary)		0·19		
HH2B	14·42*	0·16	0·24	0·48
HH2C (sorbitic)		0·31		

* The tests were made in duplicate on each rail.

The report demonstrates that the rail treated by the Sandberg sorbitic process showed, under the sliding abrasion test, which is the nearest approximation to the actual wear to which rails are subjected when in use, a resistance superior to that of the untreated rail in the ratio of 300 to 100 : under simple rolling abrasion in the ratio of 290 to 200 ; and under the shock test in the ratio of 48 to 42. The Sandberg sorbitic process, therefore, increases the resistance of the rail both to wear and fracture.

The process has also been applied to the treatment of tramway rails, and the following table, by Mr. Robert B. Holt, the Leeds City Highways and Permanent Way Engineer, will be found of interest.

TABLE III.—*Behaviour in Service of Basic Bessemer Sandberg Steel Tramway Rails, Untreated and Treated.*

—	(1) Ordinary "Sandberg."	(2) "Sandberg" Air-cooled (Sorbitic).
Location (outgoing track)	Boar Lane, near Mill Hill	Boar Lane, between Mill Hill and Alfred-street.
Alignment ..	490 ft. radius ..	245 ft. radius and straight.
Gradient ..	1 in 116 (up) ..	1 in 116 (up) and 1 in 350 (down).
Speed	12 m.p.h.	12 m.p.h.
Weight	11 tons (4 wheels, 2 motors), wheels 30 in. diameter	11 tons (4 wheels, 2 motors), wheels 30 in. diameter.
Period of test ..	12 months. Cars carried, 533,333	12 months. Cars carried, 533,333.
Length of test rail	40 yards of rail ..	120 yards of rail.
Composition ..	Carbon 0·52 per cent., silicon 0·315 per cent., manganese 1·12 per cent., phosphorus 0·07 per cent., Basic Bessemer process	Carbon 0·51 per cent., silicon 0·316 per cent., manganese 1·14 per cent., phosphorus 0·07 per cent., basic Bessemer process.
Tensile test ..	54·8 tons per square inch. Elongation 15 per cent.	58·2 tons per square inch. Elongation 13 per cent.
Impact test .. Supports 3 ft. 6 in. apart, 12 ft. drop. Weight of tup 2,240 lb.	1 5/8 in. deflection ..	1¼ in. deflection.
Crushing test .. 50 tons pressure. Diameter of ball 19 mm.	3 mm. impression ..	2·7 mm. impression.
Bending test ..	Rail curved to 20 ft. radius. No sign of fracture	Rail curved to 20 ft. radius. No sign of fracture
Average depth of Wear	0·1406 in. = 24·99 per cent. of available depth.	0·0468 in. = 8·32 per cent.
Maximum depth of wear	0·1562 in. = 27·76 per cent.	0·0625 in. = 11·11 per cent.
Minimum depth of wear	0·1250 in. = 22·22 per cent.	0·0312 in. = 5·54 per cent.

The average depths of wear recorded above, 8·32 per cent. in the case of the treated rail and 24·99 per cent. in that of the untreated one, indicates an increased durability of over 200 per cent. in favour of the former for the period (twelve months) mentioned. Figs. 5 to 8, annexed, are micrographs showing the texture of both the treated and untreated tramway rail heads. The micrograph, Fig. 5, of the untreated rail shows the pearlitic structure which reigns throughout the head; whilst Fig. 8, of the Sandberg-treated rail, illustrates the sorbitic structure which goes down to a depth of 1 in. from the surface, or more than the depth available for wear.

In this conjunction, the following statement taken from the proceedings of the conference of the Municipal Tramways Association, held in Glasgow, from September 27 to 29, 1911, is of special interest : "The cost of the rail is only 20 per cent. of the cost of renewal of track, yet, the rail alone is the determining factor in the life of the track. Too much attention, therefore, cannot be given to this question, and the very best steel procurable for this purpose is the cheapest economically."

In Table IV, page 628, are given the test figures on 130-lb. rails, made for the Pennsylvania Railroad by the Bethlehem Steel Company, Sparrow's Point, Maryland, United States, in December, 1917. The figures in heavy black type apply to the rails treated by the Sandberg sorbitic process, the others apply to the rails as rolled. The positions of the Brinell tests are shown in Fig. 9.

Another interesting series of results which illustrated the value of the process refer to tests made on 46 Kg. French Government rails, Fig. 10, also at the works of the Bethlehem Steel Company. These are contained in Table V, and the micrographs, Figs. 11 to 18, page 627, show the texture of the treated and untreated specimens at magnifications of 250 and 1,000 diameters.

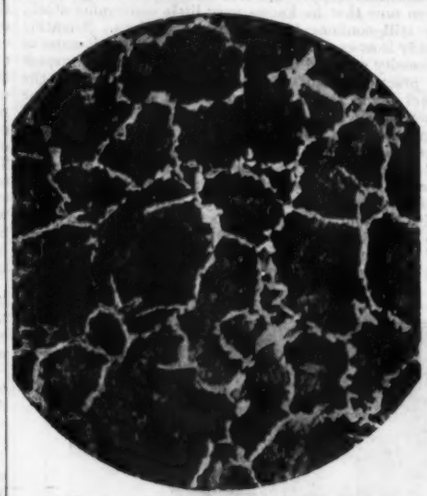


FIG. 5. SILICON STEEL; UNTREATED.

FIG. 6. SILICON STEEL TREATED.

MAGNIFICATION 250 DIAMETERS.

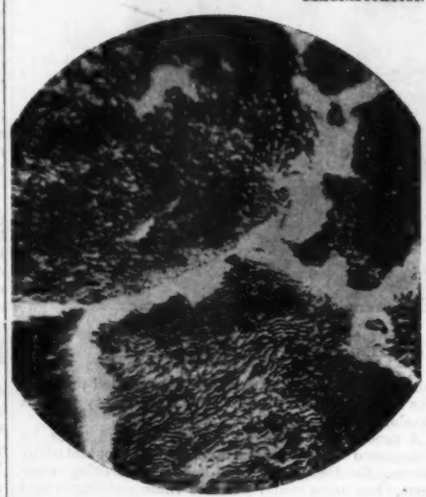
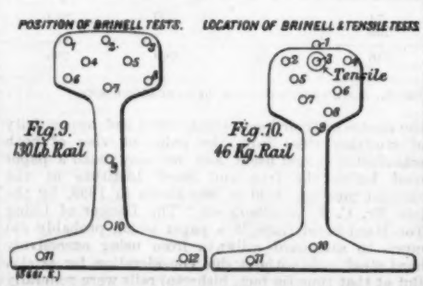


FIG. 7. PEARLITE STRUCTURE THROUGHOUT THE HEAD OF RAIL.

FIG. 8. SORBITIC STRUCTURE TO A DEPTH OF 1 IN. FROM THE SURFACE.

MAGNIFICATION 1,000 DIAMETERS.

FIGS. 5 TO 8. SPECIMENS FROM LEEDS TRAMRAILS.



From the Tables IV and V two features are clearly evidenced. In the first place it will be seen that the Sandberg sorbitic process greatly increases the tensile breaking strength of the steel, whilst elongation under tensile stress has decreased in a marked degree. In this connection it is curious to note from Table IV., page 628, that the elongation under the drop tests is frequently greater in the case of the treated rail than in that of the untreated. In the second place the Brinell hardness number is much higher in the treated rail at the top of the head, the part most subject to wear.

Results have recently been obtained from some tyres supplied early in the year to the Metropolitan Railway. Six treated and two untreated tyres from the same cast were fitted to an Inner Circle motor coach, and after six months constant use the gaugings show the treated tyres, as in the case of the treated rails, to have about twice the life of the untreated, and further orders for Sandberg sorbitic tyres have therefore been placed.

In the case of tyres the effect of the process is shown by Tables VI and VII, page 629, which give the results of drop and tensile tests carried out on three specimens, Nos. 17 and 18 being Sandberg treated,

FIG. 11. SPECIMEN A.A. TREATED FOR 5 MIN.

FIG. 13. SPECIMEN A.B. UNTREATED.

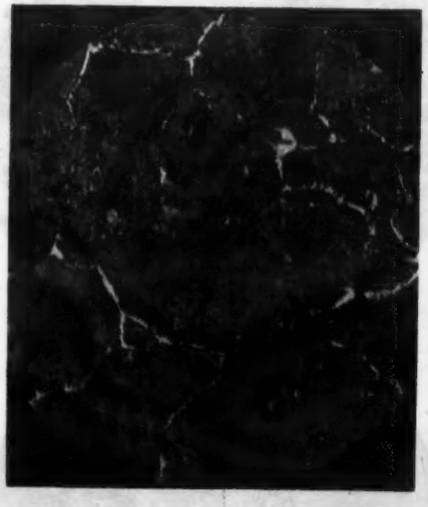


FIG. 15. SPECIMEN C.A. TREATED FOR 5 MIN

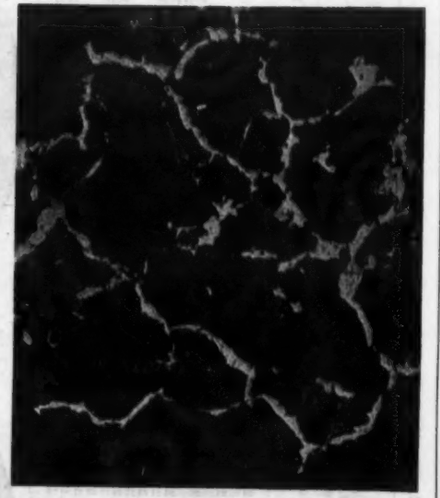


FIG. 17. SPECIMEN C.B. UNTREATED.

250 DIAMETERS.

FIG. 12. SPECIMEN A.A. TREATED FOR 5 MIN.

FIG. 14. SPECIMEN A.B. UNTREATED.

FIG. 16. SPECIMEN C.A. TREATED FOR 5 MIN.

FIG. 18. SPECIMEN C.B. UNTREATED.

1,000 DIAMETERS.

TABLE IV.—TESTS ON 130 LB. FLANGE RAILS.

Heat No.	Analysis.							Drop: 2,000 lb. falling 18 ft.: Supports, 4 ft. crs.: Deflection in inches on 3 ft.					Impression 112,000 Lb. on 10 mm. Ball Depth in mm.		Tensile.		Brinell Numbers: 3,000 Kg. on 10 mm. Ball.										
	C.	Mn.	P.	S.	Si.	Cr.	Ni.	1st Blow.	2nd Blow.	3rd Blow.	4th Blow.	Total Elongation on 6".			Breaking Stress Lb. per Sq. in.	Elongation per Cent. on 2 in.	1	2	3	4	5	6	7	8	9	10	11	12
3×6761	0·600	0·63	0·022	0·039	0·094	0·33	0·76	0·7	1·3	1·8	2·3	0·47	2·5	2·5														
3×6761	0·600	0·63	0·022	0·039	0·094	0·33	0·76	0·8	1·4	1·9	2·5	0·45	3·2	3·2														
1×6762	0·633	0·62	0·024	0·056	0·103	0·27	0·78	0·7	1·2	1·6	2·0	0·60	2·2	2·1														
1×6762	0·623	0·62	0·024	0·056	0·103	0·27	0·78	0·7	1·4	broke			2·9	2·9														
1×6788	0·667	0·59	0·023	0·049	0·073	0·21	0·71	0·6	1·1	1·5	2·0	0·40	2·1	2·2	158,300	9·5	321	340	321	321	321	302	286	293	269	277	286	286
1×6788	0·667	0·59	0·023	0·049	0·073	0·21	0·71	0·8	1·5				2·9	2·9	134,900	11·0	269	277	277	286	286	269	269	269	269	269	277	286
4×6789	0·644	0·72	0·020	0·050	0·101	0·21	0·69	0·6	1·1	1·5	1·9	0·35	2·0	2·0	164,700	9·0	332	351	340	332	332	302	302	321	286	286	302	302
4×6789	0·644	0·72	0·020	0·050	0·101	0·21	0·69	0·6	1·2				2·7	2·7	142,700	10·5	286	286	286	286	293	286	286	286	293	293	302	302
3×6806	0·680	0·65	0·024	0·056	0·110	0·25	0·34	0·7	1·3	1·8	2·3	0·45	2·3	2·3														
3×6806	0·680	0·65	0·024	0·056	0·110	0·25	0·34	0·8	1·6	2·2	2·8	0·57	3·0	3·0														
1×6809	0·622	0·55	0·020	0·052	0·103	0·31	0·71	0·7	1·3	1·8	2·3	0·39	2·3	2·3	147,500	8·5	311	332	302	321	302	286	277	277	255	262	262	262
1×6809	0·622	0·55	0·020	0·052	0·103	0·31	0·71	0·9	1·5	2·0	2·6	0·52	3·0	3·0	126,500	10·5	262	255	255	262	269	262	255	255	255	262	262	262
4×6810	0·560	0·62	0·025	0·053	0·113	0·35	0·76	0·8	1·3	1·9	2·4	0·53	2·4	2·4														
4×6810	0·560	0·62	0·025	0·053	0·113	0·35	0·76	0·8	1·3	1·8	2·2	0·48	3·1	3·1														
3×6820	0·780	0·69	0·021	0·072	0·129	0·29	0·51	0·6	1·0	1·3	1·7		1·8	1·8	179,100		375	387	375	375	375	351	332	351	321	332	340	340
3×6820	0·780	0·69	0·021	0·072	0·129	0·29	0·51	0·6	1·1	1·5	2·0		2·5	2·5	146,500		321	293	321	311	321	321	311	321	321	302	332	332

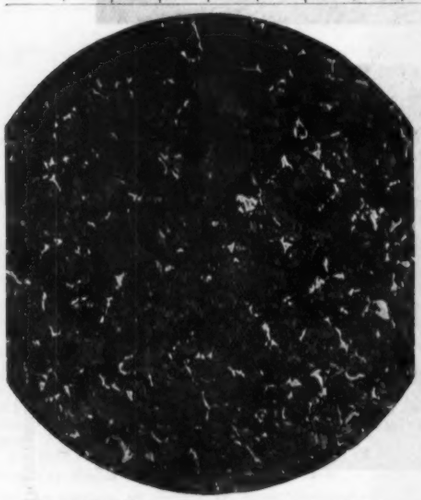


FIG. 19. SANDBERG TREATMENT OF TYRE.

FIG. 21. SANDBERG TREATMENT OF TYRE.

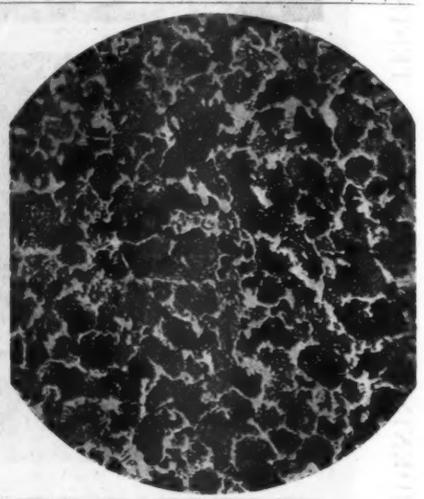


FIG. 23. WORKS USUAL TREATMENT OF TYRE.

MAGNIFICATION 250 DIAMETERS.

FIG. 20. SANDBERG TREATMENT OF TYRE.

FIG. 22. SANDBERG TREATMENT OF TYRE.

FIG. 24. WORKS USUAL TREATMENT OF TYRE.

MAGNIFICATION 1,000 DIAMETERS.

SPECIMENS FROM TYRES OF METROPOLITAN RAILWAY INNER CIRCLE MOTOR-COACH.

these showing a good sorbitic structure, whilst No. 19 received the works usual treatment, and shows a normal pearlistic steel. The treatment in this instance was effected by the Metropolitan Carriage, Wagon and Finance Company, Limited, at the works of the Patent Shaft and Axletree Company, Limited, Wednesbury. Micrographs of the Sandberg treated and of the works treated specimens are reproduced in Figs. 19 to 24, Fig. 25, of the tyre section showing the location of the Brinell tests. The figures in the two tables are self-explanatory, the Sandberg treatment, it will be seen from Table VI, greatly increases the elastic limit, whilst the Brinell hardness numbers are much higher,

Fig.25.

as evidenced by Table VII. In the Brinell tests for these tyres, a load of 3,000 kg. was applied on a 10 mm. ball for 15 seconds. The steel tyres in question had the following analysis: Carbon, 0·60; silicon, 0·356; sulphur, 0·041; phosphorus, 0·033; and manganese, 0·82 per cent.

Incidentally, and in closing, we may state that the very serious problem of rail corrugation is affected, for, whatever may be the cause of corrugation, there can be no doubt that it only occurs when the streses set up in the head of the rail are beyond the elastic limit of the steel, and as this point is raised considerably by the process corrugation, though it may not be

TABLE V.—TESTS ON 46 KG. FLANGE RAILS.

Heat No.	Test No.	Analysis. C.	Mn.	P.	S.	Si.	Cr.	Ni.	Drop Test: 2,000 Lb., falling 15 ft.: Supports, 3 ft. Crs.: Deflection in In. 1st Blow.	2nd Blow.	3rd Blow.	4th Blow.	5th Blow.	Tensile. Breaking Stress Tons per Sq. In.	Elongation per Cent. on 2 in.	Reduction of Area, per Cent.	Impression 50 Tons on 19 mm. Ball: Depth in mm.	Brinell Numbers, 3,000 Kg. on 10 mm. Ball. 1	2	3	4	5	6	7	8	9	10	11	
1×4241	A–A	0·560	0·75	0·017	0·084	0·119	0·35	0·61	1·30	2·50	3·50	Nicked and broken		55·6	11·5	13·0	2·9	248	255	255	248	255	262	262	255	262	228	217	Treated on head for 5 minutes.
1×4241	A–B	0·500	0·75	0·017	0·084	0·119	0·35	0·61	1·50	2·70	3·90	Nicked and broken		47·5	12·5	17·0	4·0	217	202	212	212	223	223	228	228	228	223	202	Untreated.
1×4241	C–A	0·500	0·75	0·017	0·084	0·119	0·35	0·61	1·35	2·50	3·30	3·70	Nicked and broken	57·2	9·5	11·9	2·9	255	255	269	255	269	269	255	241	217	228	212	Treated on head for 5 minutes.
1×4241	C–B	0·500	0·75	0·017	0·084	0·119	0·35	0·61	1·50	2·70	3·70	Nicked and broken		47·8	13·0	16·3	3·9	207	207	207	207	217	217	212	217	202	223	202	Untreated.

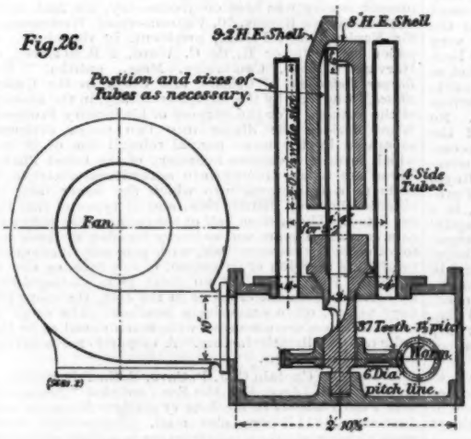
TABLE VI.—DROP AND TENSILE TESTS OF TYRES.

Cast No.	Tyre No.	Temperature. Furnace.	Start.	Finish.	Duration of Treatment. Min.	Valve Open: Turns.	Pressure of Air. Start.	Finish.	Drop Test. 1 Ton (2,240 Lb.) falling. 10 Ft.	15 Ft.	20 Ft.	25 Ft.	30 Ft.	30 Ft.	30 Ft.	30 Ft.	30 Ft.	30 Ft.	30 Ft.	30 Ft.		Tensile. Elastic Limit. Tons.	Breaking Stress. Tons.	Elongn. per Cent. on 2 in.
378A	17	790	770	610	5	¾	95	55	in. ½	in. 1/16	in. 3/16	in. 1 1/16	in. 1 1/16	in. 1 1/16	in. 2 1/16	in. 2 3/16	in. 3½	in. 3 1/16	in. Broke on to p.			40·5 (90,720 lb.)	62·3 (139,552 lb.)	15·0
378A	18	790	770	595	5	1	100	47	1/16	¼	3/16	1 1/16	1 1/16	1 1/16	2 3/16	3	3 ¼	3 ¼	4 1/16	4 ¼	4¾	5 1/16	Broke at bottom	36·8 (82,432 lb.)	62·2 (139,328 lb.)	16·0
378A	19	Works usual treatment.							½	1/16	1 1/16	2	3	3¾	4¾	Broke.								28·2 (63,168 lb.)	50·6 (113,344 lb.)	22·0

TABLE VII.—BRINELL TESTS OF TYRES.

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
17	293	293	302	286	286	302	293	311	311	277	286	286	286	286	286	262	269	269	269	269	269	262	262	255	262	262	262
18	286	293	293	286	293	293	302	302	311	277	286	286	293	302	293	277	269	262	269	269	277	262	262	262	255	262	262
19	248	248	248	235	241	241	241	235	235	235	228	235	235	228	241	228	228	228	228	228	235	235	228	228	223	228	223

Fig. 26.



prevented entirely, will at all events be considerably retarded.

Finally, it may be mentioned that Messrs. Sandberg have presented the process, free of royalty or licence fees, to the Government for use on munitions of war, and that after exhaustive tests, it was accepted by the Ordnance Committee and adopted by the Ministry of Munitions for the purpose of reclaiming high explosive shell steel which failed to fulfil the requirements of the specification. It has been used for this purpose by a large number of forge-masters in this country and also in Canada and the United States, with the result that several millions of shell forgings which would otherwise have been rejected have been rendered serviceable.

Fig. 26, illustrates the apparatus for the Sandberg treatment of shells.

The shell is mounted on a vertical tube pierced for the emission of compressed air supplied by the fan shown. The shell is slowly revolved by worm gearing and whilst moving, is also played upon by jets of air issuing from slots or holes in three or four vertical pipes set at intervals round its circumference.

THE OPTICAL SOCIETY

At a meeting of the Optical Society held at the Imperial College of Science and Technology on the 14th November, the president, Professor F. J. Cheshire, C.B.E., in the chair, the following papers were considered. The first was by Mr. T. Smith, B.A., on "Some Generalised Forms of an Optical Equation."

He said, the paraxial equation for refraction at a spherical surface

$$\frac{\mu'}{x'} - \frac{\mu}{x} = \frac{\mu' - \mu}{r}$$

connecting the distances x and x' of conjugate points on the axis from the vertex may be made an exact equation for all rays by the inclusion of an additional factor. Any ray which intersects the axis is completely specified by two of three angles α, γ, δ, some one of which vanishes when the rays are refracted without axial aberration. The angle α is the semi-angular aperture at which the ray is refracted; γ is the angle made with the axis by the line joining the centre of curvature of the surface to the intersections of the incident and refracted rays with the aplanatic surfaces; δ is the deviation suffered by the ray. The form taken by the equation depends upon which pair of angles is selected. If

[$\epsilon = \tan\frac{1}{2}\alpha \tan\frac{1}{2}\gamma$, $\eta = \tan\frac{1}{2}\gamma$, $\epsilon = \tan\frac{1}{2}\gamma \tan\frac{1}{2}\delta$,

the equations are

(1) $$\frac{\mu'}{x'-\lambda} - \frac{\mu}{x-\lambda} = \frac{\mu'-\mu}{r-\lambda}$$

where $$\lambda = \frac{2\epsilon r}{1+\epsilon}$$

(2) $$\frac{\mu'(1-\eta)}{x'} - \frac{\mu(1+\eta)}{x} = \frac{\mu'-\mu-(\mu'+\mu)\eta}{r}$$

or $$\frac{\mu'+n}{x'} - \frac{\mu+n}{x} = \frac{\mu'-\mu}{r}$$

where $$n = \frac{2\mu\mu'\eta}{\mu'-\mu-(\mu'+\mu)\eta}$$

(3) $$\frac{n'(1+\epsilon)}{x'+2q} - \frac{\mu(1-\epsilon)}{x+2q} = \frac{\mu'-\mu-(\mu'+n)\epsilon}{r} = \frac{n'-\mu}{r+q}$$

$$= \frac{\mu'-\mu+(n'+n)\epsilon}{\gamma+2q}$$

where $$q = \frac{(\mu'+\mu)\epsilon r}{\lambda'-\mu-(\lambda'+\mu)\epsilon}$$

Equation (1) expresses the result in terms of a displacement of the equivalent unit point and a shortening of the radius of curvature of the surface equal to λ. Equation (2) gives the exact law of refraction in the form of corrected equivalent refractive indices, and equation (3) in a form combining the characteristic features of both (1) and (2). When a series of surfaces is met equation (1) is generally found most convenient for numerical use. The advantage of the equations is that a knowledge of ϵ, η or ϵ to a comparatively low order of accuracy gives a highly accurate value, for the point of intersection of the ray with the axis. The departure from the sine condition is determined with corresponding accuracy.

A number of auxiliary formulæ are given for use in the application of the new equations. In an appendix numerical examples of the application of the equations to a series of large aperture cemented lenses are given.

Mr. H. S. Ryland then presented "Notes on the Design and Manufacture of Binoculars."

He discussed the faults which usually develop in binoculars from rough usage and ordinary wear; also the changes of design necessary to overcome them. It was shown that by small changes of design the use of die castings and press work could with advantage be developed. The more extensive use of moulded blanks for lenses and prisms was advocated and the methods of moulding (or pressing) glass were described. Types of optical construction were shown, and it was suggested that a "three piece cemented objective appeared to give a more brilliant image than those of the usual two pieces" construction, while owing to the flatter curves it was probably but little more expensive to produce. Various methods of adjustment were described suitable for use where instruments are, and where they are not, available. Finally, various methods of testing definition and light transmission were shown, including methods for the rapid comparison of binoculars with a measured standard.

HIRE OF RAILWAY WAGONS.—With reference to the announcement made in the Press on June 14 regarding the maximum rates fixed by the Minister of Munitions for the hire of second-hand railway wagons (see ENGINEERING, vol. cv, page 725), the Minister of Munitions has given notice that where the rate to be charged on any hire is below the maximum rate fixed for the class of wagon in question, a hiring for a longer period than that mentioned in the said announcement may, upon application to the Railway Materials Licences Department for the necessary permit, be authorised. No terms of hiring which include an arrangement for the extension of the period of hire at the option of one of the parties only will, however, be authorised.

NATIONAL FACTORIES AND DOCKYARDS.

THESE are dealt with in the tenth report of the Select Committee on National Expenditure, and we make the following extracts :—

National Factories.—Before and during the recess our sub-committee on the Ministry of Munitions visited several national factories in London, Leeds and Southampton.

The number of national factories for the production of munitions either instituted by the Ministry of Munitions, or taken over by them from private owners, now amounts to 302. They are managed by officers directly appointed by the Ministry, the Local Managing Boards, or by firms employed as agents. In all cases the original capital expenditure and the whole working cost are borne by the Ministry. The factories vary in importance from small saw mills and boxmaking factories, instituted at a cost of £1,000 or less, to the Propellant factory at Gretna, the capital cost of which was nearly £9,000,000. At nearly all the larger factories, the buildings, as well as the plant, are the property of the Ministry, while in some of the smaller cases the premises have been hired. The total capital expenditure of the Ministry on 257 of these national factories amounted on the 31st March, 1918, to £52,431,085. Further expenditure since that date on these factories and on others which were begun subsequently, is estimated to amount to about £12,000,000. The sub-committee were favourably impressed at the factories which they visited by the keenness of the management, the industry of the workers, and the excellence of the general conditions. The sub-committee are also satisfied that the policy of instituting national factories has, on the whole, borne good fruit. Massed production on a large scale, where it has been allowed a clear run, has undoubtedly made for economy in production, and, although the cost of production at national factories may have been higher than the lowest ascertained at commercial firms, the sub-committee are satisfied that their production has been generally economical. The profits, estimated by comparison of their costs with the contract prices ruling at the various dates, show that in a large number of cases the national factories have more than paid for themselves.

To what extent certain classes of national factories have been installed on an unnecessarily large scale in view of the extensions which were being concurrently carried out at the works of private firms, and whether the production of munitions might not have been accelerated by concentrating labour and materials on fewer factories, the sub-committee find it difficult to determine, owing to the constant changes of programme and of the war conditions generally ; and as the committee have carefully refrained from reporting upon extravagance or mistakes, except in cases where by so doing they hoped to prevent a recurrence, they see no purpose, in the present circumstances, in dealing at greater length with this subject. The remuneration paid to the firms for the management of the national factories was calculated at first in many instances upon an excessively liberal scale. The Committee are glad to report that in the case of the National Projectile Factories, which are factories for producing large shell, the managing firms have foregone the whole, or part, of their remuneration as from December, 1917, or earlier, while one of these firms, Messrs. Cammell Laird and Co. undertook from the first, the erection and management of the large national factory at Nottingham without remuneration of any kind.

Apart from the national factories, the Ministry of Munitions have incurred heavy capital expenditure at the works of certain firms for the production of munitions, retaining the ownership of the plant, and, as a rule, sharing the benefit of economical production. Your committee recommend that for the settlement of these questions and the numerous other questions which are likely to arise concerning claims made on, or payments due to, the Ministry, the Government should appoint a liquidator or liquidators, who should not be connected with, or confined to, the Ministry of Munitions, but should act for all the departments making war purchases ; while a permanent committee should be appointed to whom the liquidator might refer any case of contract or administrative action which might appear to him to require special investigation.

Proposed Motor Transport Depot at Slough.—During the last few weeks our sub-committee on the War Office have returned to the consideration of this matter. They have inspected the progress of the works and have taken fresh evidence. They find that the estimate of the expenditure required had been increased from the figure of somewhat over £1,000,000, which had been furnished to them in the summer, to a figure of £1,750,000. Little additional accommodation was contemplated, the increase of 75 per cent. being attributed partly to the constant rise in the cost of construction, partly to the first rough estimates not having proved reliable when examined in further detail. Your committee are surprised that the department should have prepared an estimate which, in so short a period as three months, should have been found incorrect by so large a percentage. In view of the prospect of the early termination of the war, our sub-committee urged upon the War Office that they should at once get into communication with the Ministry of Munitions with a view to ascertaining whether the Ministry would have at its disposal premises that could be released either for the storage or for the repairing, or for both, for which the establishment at Slough had been intended. This has been done, but no reply has been received as yet from the Ministry. Meantime the work at Slough proceeds, though at the moment it is being concentrated in the main upon the repair shops, and these upon a reduced scale. For these, with certain accessory buildings and works, the present estimate is £1,000,371. A considerable length of road and railway has been completed, one large lorry shelter 800 ft. by 250 ft. is almost finished, and other portions are in course of construction.

It is clear that accommodation is necessary for the storage of vehicles and spare parts, belonging to the Government, which have a value of many millions, and which, if not properly stored, will rapidly deteriorate. There is a very large number of motor vehicles at home and in foreign theatres of war which need attention.—52,130 lorries, 28,590 cars, and 33,886 cycles. An estimate has been furnished to our sub-committee by the War Office based upon an expenditure of £1,000,371 upon repair workshops at Slough, and upon an output of repaired vehicles of 100 lorries, 100 cars, etc., and 200 cycles per week for three years. All costs for labour, materials, establishment charges, and interest are included, and the capital expenditure of £1,000,371 is written down to £250,000 at the end of three years. This estimate shows a net profit on the undertaking in that time of £1,233,772. This estimate must necessarily be to some extent speculative, for the reason, among others, that the price that will be realised by the repaired vehicles must be uncertain. If it proves to be correct, the enterprise is worth pursuing, but your committee can express no opinion as to whether the estimate is likely to be realised. The plans provide for the construction, at a considerable cost, of barracks on a large scale for the housing of military labour, both men and women. Our sub-committee have been informed that these plans are such as to allow portions of these barracks to be converted into quarters for civilian families. We are of opinion that, if the scheme is to proceed, the necessity for providing any housing accommodation should be reviewed, and, if such accommodation is found to be necessary, the question should be considered how far the present plans meet the requirements of the new situation.

We recommend :—(1) That the estimate referred to should at once be subjected to independent expert examination ; (2) That the Ministry of Munitions should be required to give an immediate reply to the inquiry of the War Office as to the availability of alternative premises, both for the storage and for the repair of motor vehicles ; (3) That the Government should review the question of proceeding with the works at Slough in the light of the information so obtained ; (4) That, if the works are to proceed, the proposals with respect to the housing of the personnel should, in particular, be re-examined.

The Royal Dockyards.—Our sub-committee on the Admiralty has taken evidence on the subject of the Royal Dockyards, and has visited the yards at Chatham, Rosyth, and Invergordon. It was not thought necessary to extend the visits to other dockyards, as Chatham may be regarded as representative of the older establishments, and Rosyth is the most modern and indeed not yet completed. Invergordon is at present a purely temporary repairing and refitting base, which has only been brought into use as a dockyard establishment during the war. From the evidence furnished at the Admiralty, our sub-committee formed the view very strongly that for many years the dockyards have been starved in the matter of capital expenditure, and that as a consequence that they are unnecessarily costly to work, and the general impression made during the inspection of the yard at Chatham entirely bore out this view. No doubt those responsible for the presentation of the Navy Estimates year by year hesitated to recommend the large expenditure which is periodically necessary if establishments of the magnitude of the Royal Dockyards are to secure and maintain economy of production ; and this, in your Committee's opinion, is a weighty argument in favour of providing for capital expenditure, as distinct from purely re-current charges. At Chatham there is a noticeable lack of modern labour-saving plant and appliances, such as would be found in a well-equipped private yard, and it is evident that the yard requires, subject to the consideration mentioned, large capital expenditure in pursuance of a general plan of reconstruction, if it is to be truly efficient. Not only would economy be secured by the provision of the proper plant, but there would be a great saving in man-power and in time. The storage accommodation at the dockyard is scattered and very deficient and the store-houses badly equipped, resulting in extravagance in the use of labour. Moreover, the buildings appeared to be subject to excessive danger from fire.

With regard to Rosyth, a modern dockyard decided upon and begun before the war, but only brought into use after the war commenced, your Committee are not in a position to criticise the scheme from a technical standpoint, but the plan of the yard appears to be practical, and there is an absence of unnecessary detail—indeed, a great deal remains to be done before the equipment of the yard will be complete. There is a marked difference between the equipment of this yard and the older yard at Chatham, and as a consequence work ought to be carried out much more efficiently and economically. It would be an advantage if the accounts could be kept in such a form as to show, as far as possible, whether this result is in fact obtained, and what relation the saving bears to the interest on the capital expended. In common with other establishments which have had to provide at short notice for the maximum possible output during the war, Rosyth is under many difficulties so far as labour is concerned, owing to the absence of adequate housing accommodation. A large housing scheme is being carried out, under which some 1,600 houses have been erected or are in course of erection. The most usual type of house (of which there are about 1,300) is that containing a living room, three bedrooms, bathroom and scullery, for which the workmen pay rents varying, according to the size and position of the houses, from 7s. 3d. to 9s. a week, in addition to local rates and payment for gas or electric light. The cost of constructing houses of this type has increased consistently as the war has gone on, and whereas the cost of the earlier houses ranged from £250 to £280, the cost of those recently erected or still under construction is estimated to range from about £490 to £580. But even when completed there will be an insufficiency of houses for the permanent needs of the establishment, with the result that the special arrangements at present in force for bringing large numbers of the workmen daily from a distance will doubtless have to be continued. This is not satisfactory, and in spite of the fact that the war has made the cost of all buildings unprecedentedly high, it seems most desirable that accommodation should be provided locally for the permanent dockyard staff. While wages remain at their present high level the staff ought to be able to pay an economic rent. At the time of our sub-committee's visit in August, 1918, the average wage appeared to exceed £4 16s. a week for each person, including women, employed in the yard. The amount of overtime and Sunday work in the yard is considerable.

The dockyard at Invergordon differs from both Chatham and Rosyth in that it is not a permanent dockyard, but a purely temporary establishment that has been improvised during the war. Your committee understand that much important naval work has been undertaken there, and that it has been done as efficiently as elsewhere. It is probably too early for a decision to be taken as to the use of Invergordon after the war, but your committee would like to place on record their view that, before any large expenditure of a permanent character is sanctioned, the question should be fully considered whether the work now carried out at Invergordon could not, with equal advantage, be undertaken at one of the existing permanent dockyards. From the geographical and physical conditions it seems evident that the maintenance at this place of a permanent establishment would be costly in the extreme.

The future of the Royal Dockyards generally must necessarily be governed by the nature of the peace secured, but your committee would strongly urge that an exhaustive review of the capabilities and use of each separate establishment should be made at the end of the war ; that those worth retaining should be brought to the highest state of efficiency by a judicious expenditure of capital ; and that no vested interests, or historical and sentimental associations, should be allowed to stand in the way of the complete abandonment of any which, owing to changed conditions, may have ceased to be permanently useful, or are not worth the necessary expenditure to make them fully efficient.

ROYAL METEOROLOGICAL SOCIETY.

THE first monthly meeting of this society for the present session was held on Wednesday, the 20th inst., at the society's Rooms, 70, Victoria-street, Westminster, Sir Napier Shaw, F.R.S., president, in the chair. A paper by Professor R. de C. Ward, F.R.Met.Soc., of Harvard College, Cambridge, Mass., entitled '*The Larger Relations of Climate and Crops in the United States*," was read by the foreign secretary, in the absence of the author. For the purpose of his inquiry Professor Ward divides the States into two major divisions separated by the mean annual rainfall line of 20 in., which forms the eastern boundary of the Great Plains. These are again divided into agricultural districts or belts as a framework into which the larger facts of climate and crop distribution, and of types of farming are fitted. The eastern half of the country has sufficient rain in normal years and ordinary farming methods are followed. The western half, with generally inadequate rainfall, is a region of irrigation, of dry farming and of grazing. Here there are no great belts distinguished by certain dominant crops as in the east, the crops are very varied, often extensively localised. The crops in both divisions are discussed with much detail as to the influence of climatic factors. A comprehensive bibliography is appended.

A paper by Captain C. J. P. Cave, R.E., F.R.Met.Soc., and Mr. J. S. Dines, F.R.Met.Soc., entitled "*Soundings with Pilot Balloons in the Isles of Scilly : November and December*, 1911," was also read. The ascents were made to ascertain the wind structure in a place where the effect of land masses may be regarded as at a minimum. The Scilly Isles consist of a small group of islands 25 miles south-west of the Lands End. The greatest height above sea-level does not much exceed 150 ft. The period covered by the observations, November 22 to December 8, marked the setting in of a south-westerly type of pressure distribution with low-pressure over Iceland. This type became well developed by November 30, and during the rest of the period several pronounced secondaries passed across the British Isles from the Atlantic. The ascents show that the changes in wind associated with the passage of these secondaries were more marked near the surface than at greater heights. Taking the mean of the ascents the layer in which surface friction made itself felt on the wind velocity was decidedly shallower than at inland stations. The majority of the balloons were followed with two theodolites and the vertical motion computed. The average rate of ascent is found to agree closely with the value given by the formula now generally adopted in this country. There was little change in the mean rate between the ground and 4 km. height. In this particular the results differ from those obtained at inland stations where the rate of rising has been found generally to be greater in the first half kilometre than at greater heights.

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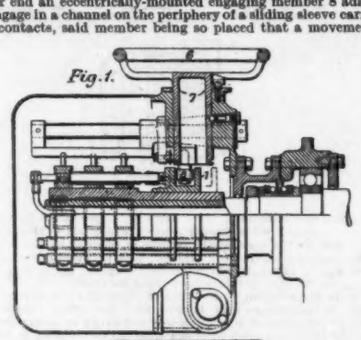
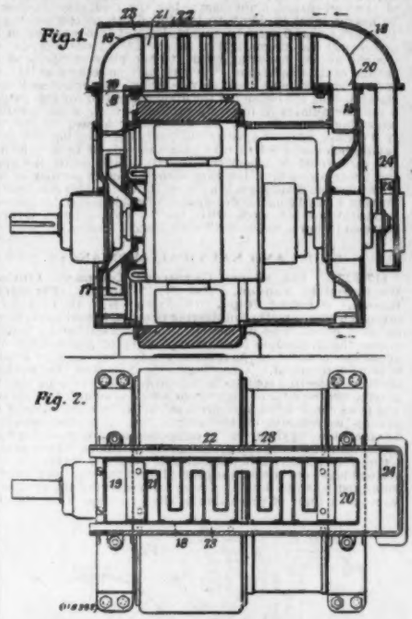
ELECTRICAL APPARATUS.

118,797. The Phoenix Dynamo Manufacturing Company, Limited, Bradford, and A. H. Bennett, Shipley. Dynamo Electric Machines. (4 *Figs.*) March 2, 1918.—This invention relates to alternating-current machines of the induction motor type and refers particularly to those devices for the short-circuiting of the rotor slip rings and releasing contact of the brushes from their slip rings in which the rotation of the operating handle shaft in one direction first moves through a crank-pin, a sliding sleeve or ring carrying the contact members into the short-circuiting position and then releases the brushes from contact with the slip rings. According to the present invention, the shaft 7 of the operating handle 6 carries at its lower end an eccentrically-mounted engaging member 8 adapted to engage in a channel on the periphery of a sliding sleeve carrying the contacts, said member being so placed that a movement of



180 deg. is necessary to move said sleeve from one to the other of its two extreme positions, while a continued movement of the engaging member at either extremity brings it clear of the contact faces in the sleeve channel into a position mid-way in said channel. The improved device allows of the use of substantial box-type brush holders situated on or below the centre line of their slip rings, the brushes of said holders being adapted to move clear of their slip rings when released from pressure through the continued rotation of the hand wheel after the operation of short-circuiting the rotor. The pressure members of the brush holders are actuated from the shaft 7 of the operating handle 6 through a slotted link 11 co-acting with a pin 12 on the handle adapted to engage the link and to move said pressure members clear of the brushes after the operation of short-circuiting the rotor (*Accepted September* 18, 1918.)

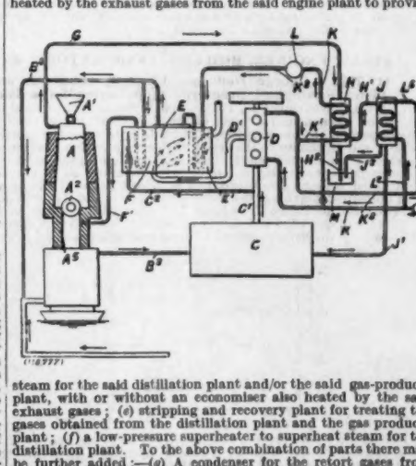
118,392. J. W. Burleigh, Burnham. Dynamo Electric Machinery. (11 *Figs.*) March 2, 1918.—This invention relates to dynamo electric machinery of the totally enclosed type and provided, external to the machine, with heat dissipating means comprising a radiator through which the air contained within the machine is circulated, as by a fan, and a protective casing or cover through which fluid external to the machine flows for cooling the radiator. In dynamo electric machines of the totally enclosed type and provided with heat dissipating means as referred to, heat dissipating means, in accordance with this invention, comprise, in combination, a radiator consisting of a casing in communication with the enclosing casing of the dynamo electric machine and provided with walls to form a sinuous or zig-zag path for the air to be cooled, a protective casing or cover for the radiator which provides paths along the sides and top of the radiator for the flow of cooling fluid, a fan mounted on one end of the armature spindle for forcing air through the radiator and a fan or a pump mounted on the other end of the armature spindle for forcing cooling fluid through the protective casing or cover. The heat dissipating means comprise a radiator 18 and a protective casing 22. The radiator comprises a structure, oblong in plan view, having openings 19, 20, at its ends for connection to extensions 8, 15, and provided interiorly with hollow walls 21 that extend vertically between the upper and lower walls and horizontally and alternately from one side wall towards the other, so as to form a sinuous or zig-zag passage. The walls 21 are, preferably, in connection with the atmosphere at their upper and lower ends and also, though not so shown, at the ends connected with the side walls. The protective casing is of U-shape in section and is such that, when in position, passages 23 for the flow of air are formed between its inner faces and the sides and top of the radiator 18. The casing 22 is at one end in direct connection with the atmosphere and at the other end is in connection with a pipe or duct 24 connected to the casing of a fan 25 mounted on the armature shaft at the commutator end of the machine and outside the bearing. Air contained in the machine is circulated by the fan 17 through the radiator 18 and the machine, and heat contained in such air is abstracted



as the air passes through the radiator by the current of air forced through the passages 23 by the fan 25. Air will also pass upwards or downward through the hollow walls 21, the flow of air, if upward, being induced by the current of air which flows along the passages 23, or, if downward, derived from the current of air. (*Accepted September* 4, 1918.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

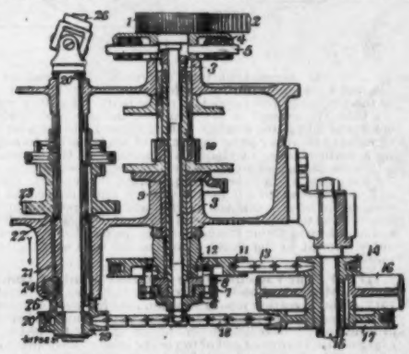
118,777. The firm Merz and McLellan, Westminster, London, and Newcastle-upon-Tyne, A. C. Michie, Jesmond, Newcastle-upon-Tyne, and E. G. Weeks, Monkseaton. Large-Scale Power Production. (1 *Fig.*) July 6, 1917.—This invention relates to the economic use of solid fuel for large-scale power production by means of low-temperature distillation of the fuel with the consequent separation of valuable distillation products and of combustible gaseous and solid residues. The present invention provides a combination of parts to constitute means for producing power from solid fuel and to recover by-products from the fuel, which parts comprise:—(*a*) A continuous (or substantially continuous) steam-heated low-temperature distillation plant for solid fuel; (*b*) a hot-coke utilisation plant consisting of coke-fed gas producer plant, with or without auxiliary coke-fired steam boilers; (*c*) internal-combustion engine plant constituting the principal utilisation apparatus for the power gases from the said producer plant and the said distillation plant, with or without provision to utilise the hot cooling water or a portion thereof from the said engine plant by forming it into the steam required by the said distillation plant; (*d*) an evaporator heated by the exhaust gases from the said engine plant to provide



steam for the said distillation plant and/or the said gas-producer plant, with or without an economiser also heated by the said exhaust gases; (*e*) stripping and recovery plant for treating the gases obtained from the distillation plant and the gas producer plant; (*f*) a low-pressure superheater to superheat steam for the distillation plant. To the above combination of parts there may be further added:—(*g*) A condenser for the retort gases from the distillation plant cooled by cooling water from the said engine plant. A is a low-temperature distillation retort for treating coal, heated by superheated steam admitted to its interior. Coal is admitted to the retort by means of a continuous-feed hopper A1 and the coke product is extracted therefrom by means of a continuous-feed device A2. The discharge by the trunk A5 is into a gas producer B, the connection between the trunk and the producer being such that the coke is not exposed to the air in its passage from the retort to the producer. The power gas obtained from the producer is led away by the main B3, to plant at C, for stripping and otherwise treating the gas. On leaving the stripping plant C, the power gas passes to internal-combustion engine plant D. The exhaust gases from the engine plant D pass by way of pipe D1 to a boiler plant E, with which boiler plant are incorporated an economiser plant E1 and a superheater F. Steam is raised in the boiler by the heat contained in the exhaust gases fed to it by the pipe D1 assisted by the hot gases leaving the superheater F, and the economiser is similarly heated. The superheater is fired by means of power gas tapped off by the pipe C2 from the main C1. Steam passes in part through the superheater by way of the pipe F1 to the distillation plant at A, while other steam passes by way of the pipe B2 to saturate the air blast for the gas producer. The gaseous efflux from the distillation plant A passes by the main G to a condenser H, which is partly or wholly cooled by means of water obtained from the water jackets of the engine plant D by means of the pipe K1. The cooling water passes by the pipe K2 and pump L to the economiser E1; the apparatus at H therefore is a combined retort gas condenser and feed-water heater. In the apparatus H the distillation products that are condensed to a liquid are collected and pass by the discharge pipe H2 to a well M, but the still gaseous contents pass by the outlet pipe H1 to a cooler J. Any products further condensed here are discharged by pipe J2 to the well M, while the still gaseous portion passes by the main J1 to the gas-stripping plant C. Cold water for the cooling of the engine plant is supplied through a pump L1 by the service K and such portion of the heated cooling water as is not required for steam raising is returned by the pipe K3 and allowed to run to waste. Tappings are taken from the service K and pipe K3 by pipes L2, L3, for the supply and return respectively of cooling water to the cooler J. (*Accepted September* 18, 1918.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

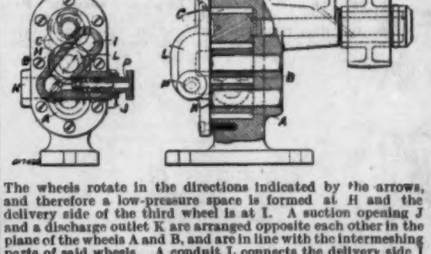
117,983. L. Oxley, C. C. H. Smith and E. Parkinson, Shipley. Milling Machines. (1 *Fig.*) August 29, 1917.—This invention relates to the feed motion of milling and like machines. The spur pinion 1, meshing with spur wheel 2, is rotated in the usual manner, the pinion being feather-keyed on shaft 3, and keyed to recessed disc 4, provided with a number of radiating spindles 5, adapted to slide towards and away from shaft 3, as controlled by the rotary speed of said shaft. Shaft 3 is adapted to slide freely through the boss of pinion 1, and to the opposite end of shaft is secured a plate 6, provided with pins 7, passing through guide plate 8, keyed to tubular shaft 9, upon which is keyed a pinion 10 engaging with a train of change gears in connection with the feed or traverse motion of the machine table. Mounted freely upon the tubular shaft 9 is a grooved pulley 11 provided with inclined cam surfaces 12, engaging with one end of pins 7 as shown, the grooved pulley 11 being rotated through a chain belt 13 engaging with a like pulley 14



carried by a stud 15, and provided with a sleeve upon which is keyed a belt pulley 16, a grooved pulley 17 being also secured upon said sleeve, the pulley being connected by a chain belt 18, with grooved pulley 19, provided with an internal conical friction surface 20, the pulley being free to revolve on shaft 20a which, during the cutting period, is rotated by the pinion 10 through an ordinary train of change gears. Upon shaft 20a is feather-keyed a sliding sleeve 21, provided at one end with a member of a claw clutch 22, the corresponding member of clutch being formed on the end of sleeve carrying spur wheel 23, rotated during the cutting operation by the train of change gears. For accelerating the return speed of the table when desired, a lever is connected to a toothed shaft 24 which, when operated, causes sleeve 21 to slide in the direction of arrow. The teeth on shaft 24 mesh with a rack 25, so that when shaft 24 is turned in a rotary direction for sliding the members of claw clutch 22 out of mesh, and the opposite end of said sleeve into engagement with the internal friction surface 20, shaft 20a and attached tubular shaft 26 are rotated at an accelerated speed. (*Sealed.*)

PUMPS.

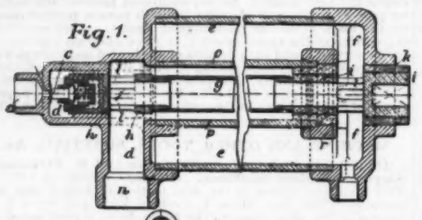
117,858. A. Herbert, Dunley Manor, near Whitchurch, and J. Ridley, Coventry. Rotary Pumps. (2 *Figs.*) August 20, 1917.—This invention relates to rotary pumps of the type wherein two meshing spur wheels are driven by a third spur wheel, all the wheels being peripherally surrounded by the casing, and the inlet to the pump chamber is on the disengaging side of the first-mentioned two wheels and the outlet is on the engaging side. According to this invention, in a rotary pump of the type described, the three wheels A, B, C, are arranged substantially in a line, with the third or driving wheel C at the end.

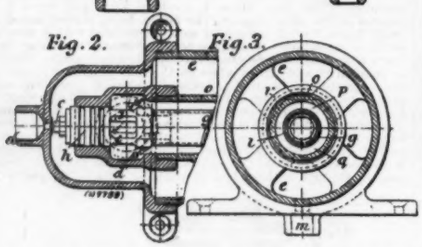


The wheels rotate in the directions indicated by the arrows, and therefore a low-pressure space is formed at H and the delivery side of the third wheel is at I. A suction opening J and a discharge outlet K are arranged opposite each other in the plane of the wheels A and B, and are in line with the intermeshing parts of said wheels. A conduit L connects the delivery side I of the third wheel C with the outlet K. A spring-loaded relief valve P is provided and connects with the conduit L so as to form a by-pass from the outlet to the inlet side of the pump when the outlet is closed. (*Sealed.*)

RAILWAYS [AND TRAMWAYS.

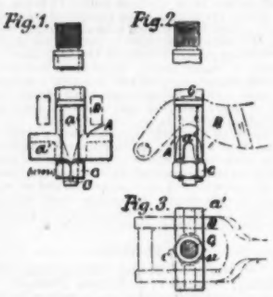
117,799. R. Sawyer, Worthing. Steam Heating Systems. (3 *Figs.*) May 24, 1918.—The invention relates to steam heating systems for the heating of railway carriages in which the supply of steam to each radiator is automatically controlled by a thermostatic valve in addition to any manual control which may be provided. According to the invention, the tube of the thermostatic device forming the return circuit for the steam is surrounded by a coaxial tube leaving an air space of annular cross-section open to the atmosphere between the two tubes. The expansion of the inner tube consequently depends on the difference between its temperature and that of the atmosphere. A steam inlet *a* leads through a port controlled by a thermostatic valve member *c* to a header *d*, whence the steam passes through an outer radiator tube *e* to a header *f* and returns





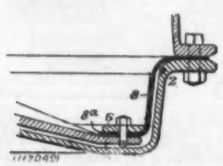
by a central thermostatic tube *g* screwed at one end into a member *h* containing the means for transmitting the expansion of the tube to control the closing of the port. The other end of the tube *g* is screwed on to a member *i*, the outer end of which is screwed into a ring *k*, which is itself screwed into the header *f*. Openings *j* in webs *l* allow any water of condensation to escape by a drain pipe *m*. A similar arrangement at the member *h* allows the discharged steam and water of condensation to escape by the outlet *n*. A tube *o* surrounds the thermostatic tube *g* and is separated from it by the space *p* which is open to the atmosphere at *p*1. One end of the tube *o* is screwed into the header *d* and the other end of the tube fits over the plain cylindrical end of a sleeve *q* fitting steamtight over the member *i*, a circular nut *r* screwed to the sleeve *q* holding the tube *o* in position. (*Sealed.*)

117,851. The Vacuum Brake Company, Limited, London, and G. Mitchell, London. Brakes. (9 *Figs.*) August 7, 1917.—This invention relates to piston rods for use in connection with railway-brake cylinders, and consists in an improved method of forming and attaching the crosshead whereby the piston rod engages with the forked end of the brake lever. According to the improved method of construction, the cross-head A consists of a central body, an upwardly-projecting tubular extension *a* and



two laterally-projecting arms *a*1, *a*1, the latter for engaging with the forked end of the brake lever B. The piston rod C traverses the tubular body portion *a* of the crosshead; and in applying the former to the latter, a certain degree of clearance between the two parts is left, with a view to permitting the crosshead A to adjust itself to the forked end of the brake lever B in the event of the latter being out of alignment. The crosshead A is secured in position upon the piston rod C by means of a nut *e* and locking pin applied to the projecting extremity of the rod. (*Sealed.*)

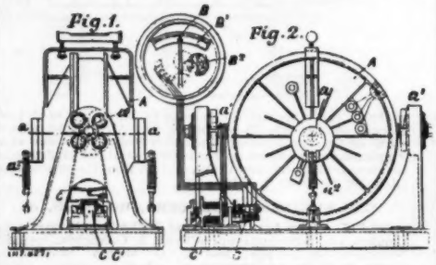
117,949. E. S. Luard, London. Vacuum Brake Apparatus. (2 *Figs.*) August 9, 1917.—This invention relates to "diaphragm cylinders" of the type used in vacuum brake apparatus and in which the brake operating piston consists of a flexible diaphragm, the outer edge of which is held between



flanges on upper and lower parts of the brake cylinder and the inner edge of the diaphragm is held between upper and lower plates, the usual piston rod being secured to the lower plate. According to the present invention, a metal ring 8 (which may be of cast-iron), having the form, or approximately the form, of an inverted truncated cone, and of a size to nicely fit the interior of the pan-shaped diaphragm 2, is placed in the diaphragm, the entire outer face of the said ring being a plain smooth surface against which the inner side of the diaphragm lies when in the lower or "brake off" position; this metal ring is relatively or comparatively deep, having a depth equal to about half the depth of the pan-shaped diaphragm; but the ring may, if desired, be nearly equal in depth to the full depth of the diaphragm. The metal ring 8 may be simply dropped into position in the pan-shaped diaphragm, and in this case is a loose ring, i.e., not secured by any fastening means to the plate or plates at the bottom of the diaphragm. The ring may be secured at its lower end or edge to, and preferably between, the upper and lower plates 6, 4, at the bottom of the diaphragm, and for this purpose a suitable number of inwardly projecting lugs, or an inwardly-projecting flange 8a may be provided or formed on the ring at its lower edge or smaller diameter, the said lugs or flange having holes adapted to take over the ends of bolts (which in this case would be longer than usual), which secure the upper and lower plates 6, 4, together with the lower portion or edge of the flexible diaphragm 2 between them. In this construction the ring 8 may be made of comparatively thin metal, for instance, enamelled pressed steel, with the above-mentioned inturned flange on its lower end or smaller diameter. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

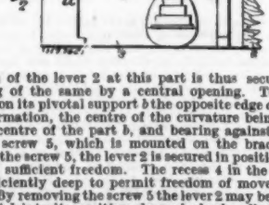
117,827. The Sperry Gyroscope Company, Limited, Westminster, London, and N. Minorsky, Petrograd, Russia. Steering Ships. (3 *Figs.*) May 31, 1917.—This invention gives a method of steering based on the principal known in other connections of measuring and indicating by suitable means the gyroscopic reaction or "force of precession" of a gyroscope mounted on the revolving body whose angular velocity is to be determined. According to the invention, the improved method of steering consists in measuring the gyroscope reaction or force of precession of a gyroscope which is mounted on the ship and is so constructed and arranged as to be responsive to the yawing movements of the ship; the apparatus (which is designated a "gyrometer"), comprises a gyroscope having a casing which is free to swing, against the resistance of a constantly-acting force, about a horizontal axis arranged transverse to a vertical plane containing the centre line of the ship, and which is connected to an indicating device for measuring the gyroscopic reaction or force of precession of the gyroscope when the ship



yaws. The gyrometer comprises a gyro-casing A containing a gyro-wheel whose axis of rotation is indicated by *a*. This gyro-casing is pivoted at *a*1, *a*1, to a frame A1, which is mounted on the ship with the axis of rotation *a* arranged parallel to the centre line of the ship. The gyro-casing is provided with two tension springs *a*2, *a*2, serving to normally maintain the axis of rotation *a* horizontal. Thus when the ship on which the gyrometer is mounted commences to yaw, the gyro-casing will move in one direction or the other, about the axis of the pivots *a*1, *a*1 and against the resistance of one or the other of the springs *a*2, *a*2. As the extension of the said spring is proportional to the gyroscope reaction or force of precession of the gyroscope, which in turn is proportional to the angular velocity of the ship, measurement of the angle through which the gyro-casing moves about the axis of the pivots *a*1, *a*1, will show the actual angular velocity of the ship. This measurement is effected by a pointer B and a graduated scale B1, the former being operated by a step-by-step motor B2 controlled by a transmitting switch C which is driven by a motor C1. (*Accepted August* 14, 1918.)

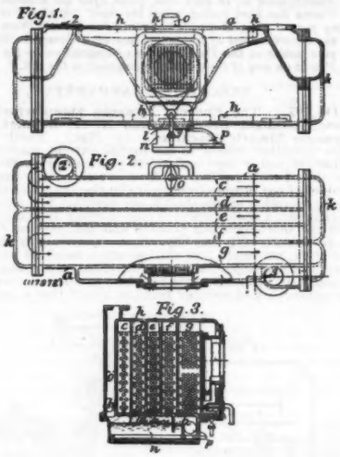
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

117,762. George Hodgson, Limited, Bradford, and C. Lister, Frizinghall, Bradford. Stop-Motion Mechanism. (3 *Figs.*) November 21, 1917.—This invention relates to stop-motion mechanism for looms of the class which brings about a stoppage of the loom on the shuttle failing to enter the shuttle-box, and especially to that class of this stop-motion mechanism wherein the leading finger of the stop rod is made to strike or come in contact with a bunter lever mounted on a bracket situated beneath the breast rail or breast beam of the loom. A indicates a portion of the end frame of a loom and B the wooden breast rail or beam. The lever 2 is made with a semicircular notch *a* in one edge and this is arranged to take over a correspondingly shaped projection *b* formed on the bracket 3. The



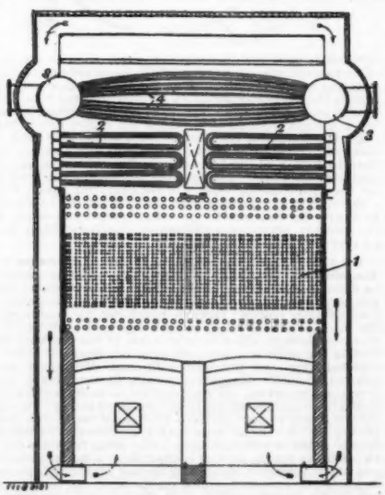
full width of the lever 2 at this part is thus secured without weakening of the same by a central opening. To secure the lever 2 upon its pivotal support *b* the opposite edge *c* is made of a curved formation, the centre of the curvature being coincident with the centre of the part *b*, and bearing against this curved part is a screw 5, which is mounted on the bracket 3. By adjusting the screw 5, the lever 2 is secured in position and yet is permitted sufficient freedom. The recess 4 in the bracket 3 is made sufficiently deep to permit freedom of movement of the lever 2. By removing the screw 5 the lever 2 may be moved from its support *b* into its position shown in broken lines, and withdrawn through the opening *d* and in the end frame A without displacing any other part in connection therewith. (*Accepted August* 8, 1918.)

117,972. The Contraflo Condenser and Kinetic Air Pump Company, Limited, and C. F. Higgins, Westminster, London. Steam Condensers. (4 *Figs.*) August 21, 1917.—This invention relates to steam condensers of the tubular surface type in which a steam cleansing device precedes a number of condensing compartments formed by partitions dividing the structure, the partitions having ports so arranged as to constrain the steam to take a tortuous course through said compartments. The present invention consists of a particular construction, combination and arrangement of parts comprising essentially, in combination, a structure containing tubes for the circulating of the condensing water, partitions dividing the structure into compartments, ports in the partitions so arranged and located as to constrain the steam to take a tortuous path through said compartments, and a removable hot-well having a cover adapted to form a removable closure for the opening in the bottom of the structure. The body of the condenser *a* is divided by partitions into compartments, *c*, *d*, *e*, *f*, and *g*, which have communicating steam ports *h* so arranged that the steam takes a



zig-zag course through the condenser. Two of the partitions are also provided with smaller ports *l* which allow the condensate to flow to the condensate outlets *m* leading to the hot-well *n*, the last compartment *c* and hot-well *n* communicating with a passage *o* through which aerated vapour may escape to the atmosphere, the condensate flowing away through the outlet *p*. The first condensing compartment *g* contains two groups of tubes and is advantageously larger than the other compartments, with the object of providing less resistance to steam flow. The water heads *k* are so arranged that the condensing water passes through the condenser three times, the passage of the water being as follows. Condensing water enters the inlet 2 and passes through the tubes in the compartments *c* and *d* in parallel, thence through the tubes in the compartments *e*, *f*, in parallel, thence through the two groups of tubes in compartment *g* in parallel, and is finally discharged through the outlet 3. (*Sealed.*)

118,310. Babcock and Wilcox, Limited, London, and J. Kennal, London. Steam Boiler Installation. (2 *Figs.*) August 17, 1917.—This invention relates to an improved steam boiler installation of the type comprising a steam generator proper, a superheater, and a reheater for the steam. A novel feature of the invention is the disposition of the reheater above the superheater; the generator, superheater and reheater being in superposed relationship. The generator proper 1 is of the well-known Babcock and Wilcox stationary or marine type. Above the generator proper is the superheater 2, which is preferably of the U-tube type. Above the superheater 2, in turn, is the reheater comprising cylindrical vessels 3, having suitable



inlets and outlets, joined by tubes 4; the arrangement being such that the steam may flow directly from one vessel 3 to the other through the tubes 4. A baffle or damper serving to control the passage of gaseous products of combustion over the superheater 5 and reheater tubes is mounted for vertical sliding movement, being operable by means of gearing. When the baffle is raised to its highest position a clear passage is open for the gases to pass directly over the superheater tubes without their passing over the reheater tubes. According to the extent to which the baffle is raised, a greater or less area open to the passage of gases in among the superheater tubes will be presented whereby the degree of superheating action effected in the reheater may be conveniently regulated. (*Sealed.*)